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EFFECT OF VACCUUM LEVEL, PULSATION RATIO, CLAW SIZE AND USING DUOVAC UNIT ON PERFORMANCE OF MACHINE MILKING OF FRIESIAN COWS

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ABSTRACT

The main objectives of this study were, to investigate the influence of different vacuum levels (VL), pulsation ratio (PR), claw size (CS) and connection of Duovac unit on characteristics of milking machine, in order to provide preliminary information for future trials on milk flow rate and milking time of Friesian cows. The present study was carried out at Sakha Animal Production Research Station, Kafr El-Sheikh Governorate. Results revealed that machine milking yield (MMY) increased ($P<0.05$) from 8.7 kg at VL of 48 kp_a to 9.0 and 9.05 kg at VL of 50 and 52 $kp_{a,}$ respectively. Total milk yield (TMY) increased ($P<0.05$) as the VL increased from 48 (8.9 kg) up to 52 Kp_a (9.8 kg). Stimulation time (ST) was shorter ($P<0.05$) at 50 Kp_a than at 52 Kp_a (10.4 vs. 10.9 sec). Machine milking time (MMT) decreased ($P<0.05$) from 4.4 to 3.9 min by increasing VL from 48 to 50 kp_a and to 3.5 min at 52 kp_a. Stripping milk yield (SMT) only increased ($P<0.05$) from 0.6 min at 50 kp_a to 0.9 min at 52 kp_a. Total milking time (TMT) decreased ($P< 0.05$) from 4.9 min at 48 kp_a to 4.6 and 4.4 min at 50 and 52 kp_a, respectively. Milk flow rate (MFR) increased ($P<0.05$) from 2.0 to 2.3 kg/min at 50 kp_a and to 2.8 kg/min at 52 kp_a. Stripping milk yield (SMY) relative to TMY was higher (2.7%, $P<0.05$) for 48 Kp_a than 50 and 52 Kp_a (2.3 and 2.4%). Values of MMY decreased ($P<0.05$) only by changing PR from 65:35 up to 70:30 (8.7 vs. 9.2 kg). SMY decreased ($P<0.05$) by 33% only with changing PR from 60:40 to 65:35. TMY decreased ($P<0.05$) from 9.7 to 9.4 kg by changing PR from 60:40 to 65:35. However, changing PR from 65:35 to 70:30 reduced ($P<0.05$) TMY from 9.4 to 8.9 kg. ST decreased ($P<0.05$) from 11.3 to 10.5 sec only by changing pulsation ratio from 60:40 to 65:35. TMT was longer (1.9 vs. 4.6 min, $P<0.05$) by changing PR from 60:40 to 65:35 and from 65:35 to 70:30 (4.6 vs. 4.5 min, $P<0.05$). SMT decrease ($P<0.05$) from 0.70 to 0.68 sec only by changing PR from 60:40 up to 70:30. MMT decreased ($P<0.05$) by changing PR from 60:40 to 65:35 or to 70:30, being 4.2, 3.9 and 3.8 min, respectively. MFR increased ($P<0.05$) from 2.3 to 2.4 kg/min only by changing PR from 60:40 to 65:35. Percentage of SMY relative to TMY decreased ($P<0.05$) from 2.7% at 60:40 to 2.4% to 2.4% at 65:35 and changing PR to 70:30 decreased ($P<0.05$) percentage of SMY to TMY to 2.3%. SMY, ST, TMT, SMT, MMT and SMY relative to TMY were higher ($P<0.05$) with claw size of 150 than 350 cm^3. However, TMY and MMY were higher ($P<0.05$) with claw size of 350 than 150 cm^3. Increasing claw size from 150 to 350 increased ($P<0.05$) MFR from 2.2 to 23.5 kg/min, increased ($P<0.05$) MMY from 8.9 to 9.3 kg and decreased TMT, whereas SMY was the same in both cases of claw size. Using Duovac unit resulted in increase ($P<0.05$) in MMY from 9.0 to 9.2 kg and in TMY from 9.3 to 9.4 kg and decrease ($P<0.05$) in ST and MMT leading to reduction ($P<0.05$) in TMT from 4.9 to 4.5 min and increase ($P<0.05$) in MFR from 2.3 to 2.5 kg/min as compared to without using. Values of SMY decreased ($P<0.05$) from 0.3 to 0.2 kg and TMY increased ($P<0.05$) and SMY relative to TMY decreased ($P<0.05$) from 2.8 to 2.1%.

Keywords: Milking machine, vacuum, pulsation, claw, Duovac unit, milk flow rate.

INTRODUCTION

The goal of the milking program is to harvest the maximum amount of high quality milk with minimum udder irritation. Milking is the most important single job on a dairy farm. All milking machines have the same basic elements such as vacuum system, pulsation equipment, milking units (cluster) and milk receptacle. The purpose of the vacuum pump is to exhaust air continuously from the milking machine system. Pulsation operation is the opening and closing of the liners in the teat cups. The pulsator alternately connects the pulsation chambers to the vacuum system of machine and to the atmosphere (Akam, 1979). The main purpose of pulsation is to maintain blood circulation through the teat (Neave, 1959). A complete breakdown in pulsation could result in serious mastitis problems and more infections were happened with wide variation in ratio and rate (Kingwill *et al*., 1979).

Several investigations had been carried out on the engineering factors affecting machine milking. They have been established that changes in the curve of the milk flow in the course of a pulsation depend on the reaction of the teat sphincter to the influence of the teat liner vacuum (Theil *et al*., 1977). Thiel and Mein (1979) reported that there are two potential uses of milk flow rate in the automatic management of dairy animals. First, as an aid to milking machine control and second as an aid to detection of health changes. The rate of milk flow changes as the characteristics of pulsation and vacuum level are changed.

Vacuum level of 51.11-57.89 kp_a is an appropriate level for Egyptian buffaloes (Hassan, 1970). The effect of different vacuum levels on total milking time, machine milk yield and milk flow rate were investigated by several authors (Aliev, 1970 and Hassan, 1970). Akam (1980) found that higher levels of vacuum would give faster milking but milking would be less complete, capital costs higher and it is popularly believed that mastitis would increased. Also, the interaction between vacuum level and pulsation ratio was studied by Mahle *et al*. (1982) on milk flow rate and udder health. The faster pulsation ratios would give faster milking but with higher operating costs (Akam, 1980; Hamed, 1982; Rosen *et al*., 1983; Hamed and Nigm, 1986 and Thomas *et al*., 1991).

On the other hand, increasing the claw volume had many effects than would be expected from placement of vacuum reservoir near the teats. Vacuum was stabilized by this reservoir but air flow through the long milk tube in response to changes in milk line vacuum was greater than it would be with smaller claw volume. The claws are different in diameter and the larger claw had an advantage on yield and flow milk rate (Thompson and Pearson, 1983). Duovac is a system represents the intermediate stage between manual and automatic cluster removal in milking machine. It make gentle massaging to the teats in a low vacuum level during stimulation and post-milking phases and reduces the risk of over milking during milking phase (Reinemann and Mein, 1994). This study aimed to determine the optimal vacuum level, pulsation ratio and claw size for maximum milk yield with the shortest machine milking time (maximum milk flow rate) of Friesian cows. Also, the effect of using Duovac unit in milking machine was investigated.

MATERIALS AND METHODS

The present study was carried out at Sakha Animal Production Research Station, Kafr El-Sheikh Governorate, belonging to Animal Production Research Institute, Agricultural Research Center, Ministry of Agricultural in cooperation with Department of Agricultural Engineering, Faculty of Agriculture, Mansoura University. The experimental work lasted 288 days during an experimental period from May 2002 to April 2003. The data for this study contained 6912 morning (a.m.) milkings for 24 Friesian cows.

Animals:

Animals used in this work were chosen from the Friesian herd raised at the station. A total number of 24 lactating Friesian cows averaged 495.6±10.0 kg LBW, and ranged between 3- 8 years of age and between the 1st and 4th parity was used in this study. The experimental animals were used after 3-4 days of colostrum suckling up to 144 days as early lactation period, thereafter the experiment was repeated for 144 days as lat lactation period to avoid the variation in lactation period between animals.

During the experimental period, animals were fed concentrate feed mixture (CFM) plus hay during summer and CFM plus berseem during winter according to NRC (1984). All cows were housed in similar dry lot housing and cows were fed identical rations and milked twice a day at 6 a.m. and 4 p.m. in nearly identical double 8 herringbone milking parlors, each parlor utilized two milkers and cows were delivered to each parlor by one stockman. Only data of morning milking was recorded.

Characteristics of milking machine:

The Gascoigne pipeline milking machine was used throughout the study. Technical information of milking machine equipment [vacuum pump model Vac 4A (cillubricated), Serial Number 482833812] are presented in table (1). It was driven by electric motor Mez. Mohelice serial Number 2386478IP44B3.

The effect with one of two types of milking claw were investigated, the first was common type with a large claw volume (350 cm^3), and used alternate pulsation. The second was more traditional type with 150 Cm^3.

Douvac system (Alfa-Laval Duovac 300) was attached during the interval studying the effect of Duovac with different levels of vacuum. Pulsation ratio and claw size.

Milk meter (Alfa-Laval Agric., Mark 5, maximum capacity 30 kg) was used to measure the total milk yield and the milk flow rate. Milk meter used in pipeline system was fixed in special stand with Duovac to measure the milk yield (kg) from each cows.

Experimental procedures:

A total of 36 trails (3 vacuum levels x 3 pulsation ratio x 2 claw size with or without Duovac), each trail lasted for 8 days (4 days during the early lactation stage and 4 days during the late lactation stage) was conducted.

Table (1): Technical information of Gascoigne melotte vacuum pump.

Tow-exhoust		Pump capacity (l/min. at 50 kpa)	Pump speed (rpm)	Pump power Kw	Pump power h.p.	Lubrication oil, g/h	Electric motor		Pump type	Electric motor speed (rpm)
Port	Sizes						Kw	hp		
50	60	1300	900	3	2.23	10	4	3	Vac4A	1440

Milking intervals for each animal were maintained at 12 hours throughout the first 144 days and at 10 hours throughout the last 144 days of the experiment. Milking machine was adjusted for different vacuum levels (48, 50 and 52 Kpa, pulsation ratio (60:40, 65:35 and 70:30) claw sizes (150 and 350 cm^3) with or without using Douvac. While, pulsation rate was set at 60 cycles per min.

When all teat cups were attached to the udder a stop watch was started, milk yield was recorded at interval of 30 seconds throughout milking and when the milk flow fell “ceased” below 0.100 kg between two consecutive readings the machine stripping was started and continued until the cessation of milk flow then the cluster was removed. The following measurements were taken for each milking: stimulation time, machine milking time, stripping time machine milking yield, total milking yield

1- *Stimulation time (ST)**:***Time elapsed from last teat cup was attached until the start milk let down .
2- *Machine milking time (MMT)**:*** The duration between the attachment of the milking until to the cessation of milk flow.
3- *Stripping time(SRT)**:*** The time was measured when milk flow rate less than 0.100 kg/min, the udder was massaged and tension below until milk flow rate stop.
4- *Total milking time (TMT)*= STT + MMT + SRT
5- *Machine milk yield (MMY)*
6- *Stripping milk yield (SMY)*
7- *Total milk yield (TMY)* = MMY + SMY
8- *Milking flow rate (MFR):* was measured during machine milking and was calculated as machine milk yield (kg)/ minute milking time.

Experimental design:

The experiment was designed such that each cow would receive every vacuum level for 48 consecutive days during which the pulsation ratio (60:40, 65:35 and 70:30) was adjusted every 16 days, claw size (150 and 350 cm^3) was changed every 8 days and Douvac was used (+) or not (-) every days). This period represented for the three vacuum levels the first 144 consecutive days as 1st phase of lactation, thereafter it was repeated for other 144 consecutive days to avoid individual variations between cows. Throughout the experimental period of 288 days a total of 6912 morning milkings were observed (3 vacuum levels x 3 pulsation ratios x 2 claw size x Douvac x 24 cows x 4 days x 2 phases) as shown in table (2). During all milkings, the pulsation rate was kept constant at 60 ppm according to (Spencer *et al.*, 1993).

There was a preliminary period of two days before applying a different vacuum level for the cows to adjust to the new adjustment level.

Table (2): Experimental design for different vacuum pressures (kp_a), pulsation rations and claw sizes (cm^3) with and without duovac for each lactation phase.

Vacuum level (kp_a)	Pulsation ratio	Claw size (cm^3)	Duovac	Number of animals (n)	Exp. Interval (day)	No. of observ-ation
48	60:40	150	With	24	4	96
			Without	24	4	96
		350	With	24	4	96
			Without	24	4	96
	65:35	150	With	24	4	96
			Without	24	4	96
		350	With	24	4	96
			Without	24	4	96
	70:30	150	With	24	4	96
			Without	24	4	96
		350	With	24	4	96
			Without	24	4	96
Total for vacuum level of 48 Kp_a				24	48	1152
Total for vacuum level of 50 Kp_a				24	48	1152
Total for vacuum level of 52 Kp_a				24	48	1152
Total for three vacuum levels				24	144	6912

Statistical analysis:

Data were statistically analyzed using a model that included effect of vacuum level, pulsation ratio, claw size and using Duovac and their interaction according to Snedecor and Cochran (1982). The significant differences among treatment groups were tested using Duncan's Multiple Range Test Duncan (1955).

RESULTS AND DISCUSSION

Effect of vacuum level on machine milking characteristics:

In milking machines, the vacuum is applied to the teat wall create pressure difference between the intra-mammary and the external atmospheric pressure, so that milk pressure can overcome the resistance of the teat sphincter muscle and flow out of the udder.

Data presented in table (3) revealed that machine milk yield, stripping milk yield and subsequently total milk yield significantly increased by increasing vacuum level from 48 to 52 kp_a. The marked increase in total milk yield was mainly attributed to increasing not only machine milk yield but also in stripping milk yield. In contrast to the present results concerning milk yield, Ivanov and Grozev (1990) reported that increasing vacuum level had no clear effect on milk yield of mechanically milked cows.

Stimulation time was insignificantly decreased (10.4 sec) at 50 Kp_a and increased ($P<0.05$) at Kp_a 52 than that at 48 Kp_a (10.6 vs, 10.9 sec). However, the difference was significant ($P<0.05$) by increasing vacuum level from 50 to 52 Kp_a (Table 3).

Table (3): Effect of vacuum level (VL) on milking characteristics of Friesian cows during morning milking.

Item	Vacuum level (Kp_a)		
	48	**50**	**52**
Milk yield (kg):			
Machine milk yield	8.7 ± 0.08^c	9.0 ± 0.09^b	9.5 ± 0.07^a
Stripping milk yield	0.2 ± 0.008^b	0.2 ± 0.006^b	0.3 ± 0.008^a
Total milk yield	8.9 ± 0.08^c	9.2 ± 0.09^b	9.8 ± 0.07^a
Stimulation time (sec)	10.6 ± 0.19^{ab}	10.4 ± 0.19^b	10.9 ± 0.27^a
Milking time (min):			
Machine milking time	4.4 ± 0.05^a	3.9 ± 0.04^b	3.5 ± 0.04^c
Stripping milk time	0.5 ± 0.01^c	0.6 ± 0.02^b	0.9 ± 0.02^a
Total milking time	4.9 ± 0.05^a	4.6 ± 0.05^b	4.4 ± 0.04^c
Machine milking characteristics:			
Milk flow rate (kg/min)	2.0 ± 0.30^c	2.3 ± 0.30^b	2.8 ± 0.40^a
Stripping /total milk yield (%)	2.7 ± 0.08^a	2.3 ± 0.07^b	2.4 ± 0.08^b

$^{a,\ b\ and\ c}$: Means denoted within the same column with different superscripts are significantly different at P<0.05.

Machine milking time gradually decreased (P<0.05) from 4.4 to 3.9 min by increasing vacuum level from 48 to 50 kp_a and to 3.5 min at 52 kp_a. The observed decrease in machine milk time was in an opposite trend of increased stimulation time by increasing vacuum level. This may indicate reversible relationship between stimulation time and machine milking time as affected by vacuum level. In parallel pattern with machine milking time, total milking time gradually decreased (P<0.05) from 4.9 to 4.6 min by increasing vacuum level from 48 to 50 kp_a and to 4.4 min at 52 kp_a (Table 3). Such trend indicated that total milking time was affected mainly by machine milking time rather than stripping milk yield and did not related to stimulation time. Also, it was found that increasing machine milking time led to marked reduction in stripping milk time. The obtained results regard to milking time agreed those found by Aliev (1970), who studied the effect of two vacuum levels (46.5 and 56.5 kpa) on total milking time of in buffaloes, founding that increasing the vacuum level caused decrease in the total milking time. In addition, Hassan (1970) investigated the effect of increasing the vacuum level from 50 to 55.2 and to 63.1 kp_a on total milking time of buffaloes. He observed a decrease in total milking time in morning and evening milkings. In this respect, Akam (1980) Mentioned that the relatively small reduction in milking time that can be achieved by increasing vacuum level is not essential in achieving large improvement in the labour economy of milking.

Milking flow rate gradually increased (P<0.05) by increasing vacuum level. The noticed increase in milking flow rate by increasing vacuum level was in relation to increased milk yield and decreased time of machine milking (Table 3). The present findings are in agreement with those reported on buffaloes by Hassan (1970), who found that average milk flow rate increased by increasing vacuum level from 50 to 55.2 and to 63.1 kp_a, but machine milk yield decreased slightly. Similar findings were reported by Schmidt *et al.* (l963) on cows..

Stripping milk relative to total milk yield increased (P<0.05) by increasing vacuum level from 48 to 50 Kp_a, but did not differ significantly between 50 and 52 kp_a vacuum levels (Table 3). Such trend may reflect higher milking efficiency at 50 or 52 than at 48 Kp_a vacuum levels. The obtained results agreed many investigators who reported that most of the milking machines are operated for milking cows at vacuum level ranging from 45 to 50 kp_a (Schmidt *et al.*, l963). However, Hassan (1970) reported that vacuum level of 51.11-57.89 kp_a is the appropriate vacuum level for Egyptian buffaloes.

Effect of pulsation ratio on machine milking characteristics:

The pulsation rate was kept at 60 cycles/min during the whole experimental period, however, pulsation ratio was changed from 60:40 to 65:35 and to 70:30. Table (4) shows the obtained values of all milking characteristics as affected by different pulsation ratios.

Machine milk yield, stripping milk yield and consequently total milk yield showed significantly (P<0.05) a gradual reduction by changing pulsation ratio from 60:40 to 65:35 or to 70:30. The optimum pulsation ratio for the highest milk yields was obtain with 60:40 pulsation ratio, regardless the other factors (e.g. vacuum level, claw size and using Duovac).

These findings are in consistent with that reported by Rosen *et al*, (1983), who reported that increasing pulsation ratio caused pronounced changes in the stripping milk yield.

The marked reduction in total milk yield with changing pulsation ratio from 65:35 to 70:30 was mainly attributed to the significant decrease in machine milk yield not in stripping milk yield as affected by changing pulsation ratio (Table 4). Decreasing machine milk yield with altered pulsation ratio from 60:40 to 70:30 may be due to that teat cups might crawl up the udder teats, and close the orifice between the teat cisterns and the gland cisterns causing the retention of more amounts of milk inside the udder cows.

Table (4): Effect of pulsation ratio (PR) on milking characteristics of Friesian cows during morning milking.

Item	Pulsation ratio		
	60:40	**65:35**	**70:30**
Milk yield (kg):			
Machine milk yield	9.4 ± 0.8^{a}	9.2 ± 0.8^{b}	8.7 ± 0.9^{c}
Stripping milk yield	0.31 ± 0.008^{a}	0.24 ± 0.007^{b}	0.20 ± 0.006^{c}
Total milk yield	9.7 ± 0.8^{a}	9.4 ± 0.8^{b}	8.9 ± 0.9^{c}
Stimulation time (sec)	11.3 ± 2.7^{a}	10.5 ± 1.8^{b}	10.2 ± 2.0^{c}
Milking time (min):			
Machine milking time	4.2 ± 0.05^{a}	3.9 ± 0.05^{b}	3.8 ± 0.06^{b}
Stripping milk time	0.70 ± 0.02^{a}	0.69 ± 0.02^{ab}	0.68 ± 0.03^{b}
Total milking time	4.9 ± 0.04^{a}	4.6 ± 0.05^{b}	4.5 ± 0.05^{b}
Machine milking characteristics:			
Milk flow rate (kg/min)	2.3 ± 0.04^{b}	2.4 ± 0.04^{a}	2.4 ± 0.05^{a}
Stripping /total milk yield (%)	2.7 ± 0.09^{a}	2.4 ± 0.08^{b}	2.3 ± 0.07^{b}

$^{a,\ b\ and\ c}$: Means denoted within the same column with different superscripts are significantly different at P<0.05.

Stimulation time significantly (P<0.05) decreased from 11.3 to 10.5 sec by changing pulsation ratio from 60:40 to 65:35. However, changing pulsation ratio from 65:35 to 70:30 significantly decreased stimulation time from 10.5 to 10.2 sec. It is worthy noting that changing pulsation ratio from 60:40 to 65:35 resulted in more pronounced reduction in stimulation time than that occurred when pulsation ration changed from 65:35 to 70:30. The shortest stimulation time was associated with pulsation ratio of 70:30 (Table 4).

As the times of machine milking and stripping milk decrease, total milking time significantly (P<0.05) decreased from 4.9 to 4.6 min by changing pulsation ratio from 60:40 to 65:35, while all milking times were not affected significantly by changing pulsation ratio from 65:35 to 70:30. The observed reduction time of total milking time when pulsation ratio was changed from 60:40 to 65:35 was in more relation to marked reduction in machine milking time than in stripping milk time (Table 4).

The detected higher milk yields with pronounced reduction in milking times by changing pulsation ratio from 60:40 to 65:35 was reflected in significant (P<0.05) increase in rate of milk flow from 2.3 to 2.4 kg/min. However, changing pulsation ratio from 65:35 to 70:30 did not effect significantly on milk flow. The nearly similarity in milk flow rate at pulsation ratios of 65:35 and 70:30 was mainly attributed to the higher reduction in total milk yield and the slight decrease in total milking time by chancing pulsation ratio from 65:35 to 70:30 (Table 4).

Percentage of stripping milk yield to total milk yield significantly (P<0.05) decreased from 2.7% at 60:40 to 2.4% at 65:35 ratio and insignificantly decreased to 2.3% at 70:30 ratio. Such trend was mainly attributed to a marked decrease in total milk yield and slight decrease in stripping milk yield (Table 4).

Several investigations had been carried out on different pulsation ratios. They have been established that changes in the curve of the milk flow in the course of a pulsation depend on the reaction of the teat sphincter to the influence of the teat liner vacuum (Theil *et al*., 1977). The main purpose of pulsation is to maintain blood circulation through the teat (Neave, 1959).

A complete breakdown in pulsation could result in serious mastitis problems and more infections were happened with wide variation in ratio and rate of pulsation (Kingwill *et al*., 1979). A faster pulsation rates and ratios would give faster milking but with higher operating costs. The relatively small reduction in milking time that can be achieved in this way are not essential in achieving large improvement in the labour economy of milking (Akam, 1980).

Most of the available studies are in accordance with the present results indicating that changing pulsation ratio had significant effect on milk yield and milking time. In this respect, Rosen *et al*. (1983) found that increasing static ratio from 40:60 to 70:30 increased peak and average milking rates as well as milking stripping yield and, decreased time to reach milk yield peak and machine milking time. Also, Thomas *et al.* (1991) found that average machine milking times were 8.44, 8.00 and 7.47 min per milking for 50:50, 60:40 and 70:30 pulsation ratios, respectively. The pulsation ratio of 70:30 yielded 3.5% milk yield per milking more than ratio of 50:50 (13.0 vs. 13.8 kg). Spencer *et* *al*. (1993) determined the effects of changing pulsation ratio on new intra-mammary infection. They found that changes of pulsation ratio at this magnitude had no damage effects upon udder health.

Effect of claw size on machine milking characteristics:

Data in table (5) show that values of milking characteristics including, stimulation time, total milking time, machine milking time and stripping milk relative to total milk yield were significantly ($P<0.05$) higher with claw size of 150 than 350 cm^3. However, total milk yield and machine milking yield were significantly ($P<0.05$) higher with claw size of 350 than 150 cm^3. On the other hand, stripping milk yield was not affected significantly by claw size, being the same with claw size of 150 and 350 cm^3. Increasing total milk yield (Machine and stripping) was associated with significantly reduction in all milking times (machine, stripping and total).

Increasing claw size from 150 to 350 significantly ($P<0.05$) increased milk flow rate from 2.2 to 2.5 kg/min as affected by the significant ($P<0.05$) increase in machine milk yield from 8.9 to 9.3 kg rather than decreasing milking time. However, stripping milk yields relative to total milk yield significantly decreased by increasing claw size. Increasing the claw volume had many effects than would be expected from placement of vacuum reservoir near the teats. Vacuum was stabilized by this reservoir but air flow through the long milk tube in response to changes in milk line vacuum was greater than it would be with smaller claw volume.

Table (5): Effect of claw size (CS) and using Duovac on milking characteristics of Friesian cows during morning milking.

Item	No	Machine milk Yield (kg)	Stripping milk yield (kg)	Total milk yield (kg)	Stimu-lation time (sec)	Machine milking time (min)	Stripping milk Time (min)	Total milking time (min)	Milk flow rate (kg/min)	Stripping milk/ total milk yield (%)
Claw size (cm^3):										
150	432	8.9 ± 0.9^b	0.2 ± 0.08	9.1 ± 0.9^b	11.1 ± 2.4^a	4.1 ± 0.6^a	0.78 ± 0.3^a	4.9 ± 0.4^a	2.2 ± 0.4^b	2.7 ± 0.9^a
350	432	9.3 ± 0.8^a	0.2 ± 0.06	9.5 ± 0.8^a	10.3 ± 2.0^b	3.8 ± 0.5^b	0.61 ± 0.2^b	4.4 ± 0.5^b	2.5 ± 0.5^a	2.2 ± 0.7^b
Duovac:										
Without	432	9.02 ± 0.9^b	0.3 ± 0.08^a	9.3 ± 0.9^b	11.5 ± 2.5^a	4.1 ± 0.6^a	0.8 ± 0.2^a	4.9 ± 0.5^a	2.3 ± 0.5^b	2.8 ± 0.9^a
With	432	9.20 ± 0.9^a	0.2 ± 0.06^b	9.4 ± 0.9^a	9.8 ± 1.5^b	3.8 ± 0.5^b	0.6 ± 0.2^b	4.5 ± 0.4^b	2.5 ± 0.4^a	2.1 ± 0.6^b

a and b: Means denoted within the same column with different superscripts are gnificantly different at $P<0.05$.

In the same time Thompson and Pearson (1983) mentioned that the claws are different in diameter and the larger claw had an advantage on yield and flow milk rate.

Effect of using Duovac unit on machine milking characteristics:

Data in table (5) show that although using Duovac in milking machine resulted in significant ($P<0.05$) increase in machine milk yield from 9.0 to 9.2 kg and in total milk yield from 9.3 to 9.4 kg, it significantly ($P<0.05$) decreased stripping milk yield from 0.3 to 0.2 kg. On the other hand, all stimulation, machine milking and stripping times significantly ($P<0.05$) decreased by using Duovac. This led to significant ($P<0.05$) decrease in total milking time from 4.9 to 4.5 min.

Such trend led to significantly (P<0.05) increased milk flow rate from 2.3 to 2.5 kg/min and decreased stripping milk yield relative to total milk yield from 2.8 to 2.1% by using Duovac unit (Table 5).

Generally, using Duovac in milking machine had beneficial effects on increasing total milk yield and decreasing total milking time of Friesian cows. Duovac is a system represents the intermediate stage between manual and automatic cluster removal in milking machine. Duovac is a system represents the intermediate stage between manual and automatic cluster removal in milking machine (Reinemann and Mein, 1994). Unfortunately, there are no information in the literature on the effect of using Duovac unit in milking machine on characteristics of machine milking of dairy cows.

Effect of interaction among different factors studied:

Only the effect of interaction between vacuum level and pulsation ratio as well as between vacuum level and using Duovac was significant on milk flow rate, however, the effect of interaction among the other factors was not significant.

Table (6): The best levels for the highest milk flow rate (MFR%) as affected by the interaction effect between factors studied.

Interaction effect					Milk flow rate	Signifi-
Factors	VL (kp_a)	PR	CS (cm^3)	Duovac	(%)	canc
VL x PR	52	70:30	-	-	2.9	***
VL x CS	52	-	350	-	2.9	NS
VL x DU	52	-	-	with	2.9	***
PR x CS	-	70:30	350	-	2.6	NS
PR x DU	-	70:30	-	with	2.5	NS
CS x DU	-	-	350	with	2.6	NS
VL x PR x CS	52	70:30	350	-	3.1	NS
VL x PR x DU	52	70:30	-	with	3.0	NS
VL x CS x DU	52	-	350	with	3.0	NS
PR x CS x DU	-	70:30	350	with	2.7	NS
VL x PR x CS x DU	52	70:30	350	with	3.1	NS

VL: Vacuum level PR: Pulsation ratio CS: Claw size DU: Duovac
***** Significant at P<0.05 NS: Not significant**

The highest milk flow rates were obtained with the highest vacuum level (52 Kp_a), the highest ratio of pulsation (70:30), the largest area of claw (350 cm^3), and using Duovac unit (Table 6).

All milking machines have the same basic elements such as vacuum system, pulsation equipment, milking units (cluster) and milk receptacle. The purpose of the vacuum pump is to exhaust air continuously from the milking machine system. Pulsation operation is the opening and closing of the liners in the teat cups. The pulsator alternately connects the pulsation chambers to the vacuum system of machine and to the atmosphere (Akam, 1979). The rate of milk flow changes as the characteristics of pulsation and vacuum level are changed. In this respect, Thiel and Mein (1979) reported that there are two potential uses of milk flow rate in the automatic management of dairy animals. First, as an aid to milking machine control and second as an aid to detection of health changes.

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استخدم في هذه الدراسة ٢٤ بقرة تمثل مواسم حليب مختلفة (١-٦ مواسم) وفترات حليب مختلفة. والهدف من الدراسة هو تحديد اثر كل من: ٣ مستويات من الضغط السالب للتفريغ (٤٨، ٥٠ و٥٢ كيلو باسكال) و٣ نسب نبض (٤٠:٦٠ ,٣٥:٦٥ و٣٠:٧٠) وكذلك حجمان لمجمع اللبن (١٥٠ و٣٥٠سم^{٣}) وذلك عند استخدام وحدة التحنين أو عدم استخدامها. وتم تقسيم التجربة إلي مرحلتين كل مرحلة ١٤٤ يوم ليكون مدة التجربة الكلية ٢٨٨ يوم وكل مرحلة تم تقسيمها إلى ٣ تحت مراحل ثانوية بحيث يكون مدة كل مرحلة ثانوية ٤٨ يوم وهى المدة التي يثبت فيها الضغط وذلك لعدد ٢٤حيوان. المعاملة لمدة ٨ يوم بحيث تتلقى كل الحيوانات كل المعاملات في نظام تبادلي متزن .جميع الحيوانات دخلت التجربة واخذ عليها قراءات حتى تتلافى الاختلافات الفردية فيما بينها. وكانت كل حيوانات التجربة تحلب مرتين يوميا الساعة ٦ صباحا و٤ عصرا وكانت تأخذ قراءة حلبة الصباح فقط وكان يتم تسجيل كمية اللبن المحلوب بالماكينة (كجم) - كمية لبن التعصير (كجم) - كمية اللبن الكلية (كجم) - زمن التحنين (ثانية) - زمن الحلب الآلي (دقيقة) - زمن التعصير (ثانية) - زمن الحلب الكلى (دقيقة) - نسبة لبن التعصير بالنسبة لكمية اللبن الكلى (%) و معدل نزول البن (كجم/دقيقة). ويمكن تلخيص النتائج المتحصل عليها كالآتي:

١- أدى زيادة ضغط التفريغ من ٤٨ إلى ٥٢ كيلو بسكال إلى زيادة معنوية في كل من: كمية اللبن المحلوب آليا من ٨,٧ إلى ٩,٥ كجم- كمية لبن التعصير من ٠,١٩ إلى ٠,٢١ كجم - كمية اللبن الكلية من ٨,٩ إلى ٩,٨ كجم - زمن التحنين من ١٠,٦ إلى ١٠,٩ ثانية - زمن التعصير من ٠,٥ إلى ٠.٩ دقيقة - معدل تدفق اللبن من ٢,٠ إلى ٢,٨ كجم/دقيقة.بينما جدث نقص معنوي في كل من: زمن الحلب الكلى من ٤,٩ الى٤,٤ دقيقة- زمن الحليب الآلي من ٤,٤ الى٣,٥ دقيقة- النسبة المئوية للبن التعصير بالنسبة لكمية اللبن الكلية من ٢,٧ إلى ٢,٤%.

٢- بتغيير نسبة النبض من ٤٠:٦٠ إلى ٣٠:٧٠ حدث انخفاض معنوي في كل من: كمية اللبن المحلوب آليا من ٩,٤ إلى ٨,٧ كجم- كمية لبن التعصير من ٠,٣الى ٠,٢ كجم- كمية اللبن الكلية من ٩,٧ إلى ٨,٩ كجم- زمن التحنين من ١١,٣ إلي ١٠,٢ ثانية- زمن الحلب الكلى من ٤,٩ الى٤,٥ دقيقة- زمن الحليب الآلي من ٤,٢ الى٣,٨ دقيقة- زمن التعصير من ٠,٧ إلى ٠,٦٨ دقيقة والنسبة المئوية للبن التعصير بالنسبة لكمية اللبن الكلية من ٢,٧ إلى٢,٣%. بنما حدثت زيادة معنوية في معدل تدفق اللبن من ٣.٢ إلى ٢,٤ كجم/دقيقة.

٣- أدى زيادة حجم مجمع اللبن من ١٥٠ إلى ٣٥٠ سم٣ إلى زيادة معنوية في كل من: كمية اللبن المحلوب آليا من ٨,٩ إلى ٩,٣ كجم - كمية لبن التعصير من ٠,٢ إلى ٠,٢١ كجم- كمية اللبن الكلية من ٩,١ إلى ٩,٥ كجم ومعدل تدفق اللبن من٢,٢ إلي ٢,٥ كجم/دقيقة. بنما جدث انخفاض معنوي في كل من: زمن التحنين من ١١,١ إلى ١٠,٣ ثانية- زمن الحلب الكلى من ٤,٩ الى٤,٤ دقيقة- زمن الحليب الآلي من ٤,١ إلى ٣,٨ دقيقة- زمن التعصير من ٠,٧٨ إلي ٠,٦ دقيقة والنسبة المئوية للبن التعصير بالنسبة لكمية اللبن الكلية من ٢,٧ إلي ٢,٢%.

٤-أدى استخدام وحدة التحنين " الديفوك " إلي زيادة معنوية في كل من: كمية اللبن المحلوب آليا من ٩,٠٢ إلى ٩,٢ كجم- كمية اللبن الكلية من ٩,٣ إلى ٩,٤ كجم ومعدل تدفق اللبن من ٢,٣ إلى ٢,٥ كجم/دقيقة. بينما حدث نقص معنوي في كل من: كمية لبن التعصير من ٠,٣ إلى ٠,٢ كجم- زمن التحنين من ١١,٥ إلي ٩,٨ ثانية- زمن الحلب الكلى من ٤,٩ الى٤,٤ دقيقة- زمن الحلب الآلي من ٤,١ إلى ٨.٣ دقيقة- زمن التعصير من ٠,٨ إلي ٠,٦ دقيقة والنسبة المئوية للبن التعصير بالنسبة لكمية اللبن الكلية من ٢,٨الى ٢,١ %. دلت مكونات التباين الممثلة للتداخل الثنائي أو الثلاثي أو الرباعي بين العوامل التي درست بينها على حدوث أعلى معدل نزول للبن عند أعلى مستوى تفريغ (٥٢ كيلو بسكال)- أكبر نسبة نبض (٣٠:٧٠)- أكبر حجم لمجمع اللبن (٣٥٠ سم٣) واستخدام وحدة التحنين (الديوفك).