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EFFECT OF FAT SUPPLEMENTATION ON PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF LACTATING FRIESIAN COWS DURING EARLY LACTATION

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ABSTRACT

Eighteen lactating Friesian cows were assigned to three equal groups to study the effect of protected fat and palm oil supplementation on digestibility coefficients, rumen fermentation, some blood constituents, milk yield and its composition and reproductive performance during early lactation. The cows in the first group were fed a basal ration only (G_1). While, in the other two groups 3% of concentrate feed mixture was replaced by protected fat (G_2) or palm oil (G_3). The experimental period lasted 15 weeks after calving.

Digestibility trials were carried out and rumen liquor samples were collected at the end of the experimental period. Blood samples were regularly collected from animals at 3 week interval starting from day 21 after calving. Milk yield was recorded weekly, while its contents were analyzed once every three weeks.

Results indicated that feeding protected fat and palm oil significantly ($P < 0.05$) increased digestibility coefficients of DM, OM, CF, EE and NFE and subsequently TDN and DCP values compared to control group, while, ruminal pH and concentration of TVFA's were not affected. Adversely, ammonia-nitrogen concentration decreased significantly ($P < 0.05$) with supplementations.

Concentrations of total protein, albumin, globulin, total lipids and HDL in blood serum were highest in cows fed ration supplemented with palm oil. Cows fed protected fat expressed the highest concentrations of total cholesterol, LDL and triglycerides compared with the other two groups.

Actual milk yield and 4% fat corrected milk were significantly ($P < 0.05$) high for cows fed protected fat followed by cows in G_3, while the lowest levels were found in the control group. Yields of milk fat, protein, lactose, total solids and solids not fat were significantly ($P < 0.05$) higher for cows fed protected fat and palm oil compared with cows fed the control rations.

Days open in G_3 recorded the longest period followed by G_2 and the least was in G_1. Number of insemination per conception in G_2 was 2.0 being insignificantly less than that G_1 and G_3 (2.5). Conception rate within 150 day postpartum and after the third insemination was significantly ($P < 0.05$) higher in G_3 compared to G_1 and G_2.

This study indicated that protected fat and palm oil supplementation in ration of dairy cows improved their feed efficiency and reduced the intake of DM and DCP required to produce 1 kg 4% FCM. Moreover, economic efficiency for cows fed protected fat and palm oil was significantly higher compared with cows fed control ration.

Keywords: Friesian cows, protected fat, palm oil, digestiblities, blood, milk composition, reproductive performance.

INTRODUCTION

During early lactation period dairy cows are often forced to draw on body reserves to satisfy energy requirements. For this reason, the addition of fat sources to the diets may be useful to overcome limitations in energy

supplies. It is well know that digestible fat supplies 2.25 times as much energy as digestible starch or sugar (Grummer and Carroll, 1991).
Cows fed added fat usually attain the peak daily milk yield a couple of weeks later and they maintain their production with greater persistency, which increases milk production by 2-12%. Also, cows fed added fat have less weight loss in early lactation, which may improve reproductive efficiency and depress cases of ketosis (McDonald *et al.*, 1995).

Fats often tend to improve rations by reducing dusting, increasing palatability and generally increase absorption of fat-soluble nutrient such as the fat-soluble vitamins (Church, 1991).

Also, the resulting milk may have a fatty acid profile with perceived human health benefits such as reduced coronary vascuced inflammatory and autoimmune disorders (Christensen *et al.*, 1994).

Fat is one of these nutrients and it apparently enhances postpartum reproduction either by increasing the energy status of the animal or by other processes independent of energy intake. In both cases, stimulation of ovarian follicular growth and luteal function (Lucy *et al.*, 1992 and Thomas and Williams, 1996). Evidence also suggests that supplemental fatty acids may improve the fertility of dairy cows by influencing energy balance in early lactation (Staples *et al.*, 1998).

Therefore, the present study was carried out to study the effects of adding protected fat or palm oil to the ration of dairy Friesian cows on digestibility coefficient, nutritive value, rumen fermentation, metabolic blood serum, milk production and its composition and reproductive performance of lactating Friesian cows during the first 15^{th} weeks postpartum.

MATERIALS AND METHODS

Eighteen healthy lactating Friesian cows from the Sakha Animal Production Research Station, Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture were used in the present study from the first week postpartum up to the 15^{th} week after calving. The animals were in the 3^{rd} or 4^{th} parity and their live weights ranged from 550 to 560 kg. The animals were randomly allotted into three equal groups (6 in each). The first group (G_1) was fed the basal ration consisted of concentrate feed mixture (CFM), berseem hay and rice straw (control group), while in the other two groups, 3% of CFM was replaced by either protected fat, Magnapac (G_2) or palm oil, Estiarin (G_3) Table (1). The offered daily feeds were assessed to cover the requirements according to NRC (2001). The CFM was individually weighed and offered twice daily during machine milking while roughages were fed in-group during the daytime. Water was available for animal all times.

At the end of the experiment, digestibility trials were conducted using three cows from each group to determine the digestion coefficient and nutritive value of the experimental rations. Feces samples were collected twice daily during the collection period (7 days). Rumen liquor samples were collected 3 hours after morning feeding on the last day of the collection period using a stomach tube. Ruminal pH was determined directly by using Beckman pH-meter. Thereafter, 1 ml of saturated mercuric chloride was added to the samples to inhibit the microbial activity and then filtered for later analysis. The concentration of ammonia-N (NH_3-N) was determined by using magnesium oxide distillation (AOAC, 1990). Total volatile fatty acids (TVFA's) were determined applying steam distillation methods (Eadie *et al.*, 1967).

Blood samples were collected from the jugular vein every 3 weeks from all the experimental cows starting from the third week postpartum and continued until the week 15 after calving. Blood serum was separated by centrifugation of clotted blood at 3000 r.p.m for 10 minutes and kept at -20°C until chemical analysis. Total protein, albumin, globulin (by difference), lipids, triglyceride, cholesterol, low density lipoprotein (LDL), high density lipoprotein (HDL), urea, glucose, activity of glutamic oxaloacetic (GOT) and glutamic pyruvic transaminase (GPT) were determined as described by Varoley (1976).

Table (1): Average daily feed intake (kg/day) by lactating Friesian cows fed the different experimental rations.

Item	Experimental group			SEM
	G1	G2	G3	
Concentrate feed mixture	9.92	8.84	9.05	-
Berseem hay	6.07	5.78	5.54	-
Rice straw	4.01	3.80	3.66	-
Protected fat	-	0.51	-	-
Palm oil	-	-	0.49	-
DM intake	17.94^{a}	17.00^{b}	16.37^{c}	0.17
TDN intake	10.82^{b}	11.69^{a}	10.84^{b}	0.12
DCP intake	1.40^{a}	1.35^{ab}	1.31^{b}	0.01

a, b and c: Value in the same row with different superscripts differ significantly ($P < 0.05$).
G1: control, G2 & G3: supplemented with protected fat and oil, respectively.

Milk yield was recorded individually weekly during the experimental period. Milk fat, protein, lactose, total solids and ash were determined biweekly from consecutive evening and morning milking by using MILKO SCAN (133 BN, FOSS Electric). The interval from calving to both of first estrus, first insemination and conception (days open) were calculated with the number of service per conception. Moreover, number of successful pregnancy was calculated during the first 150 days postpartum.

Economic efficiency of milk production calculated as follows:

Economic efficiency = income of 4% fat corrected milk / cost of feed consumption.

Whereas, the price of one ton were 1000 LE for 4% fat corrected milk, 700 LE for concentrate feed mixture, 400 LE for berseem hay, 50 LE for rice straw, 2900 LE for protected fat and 1700 LE for palm oil during year 2003.

The data were statistically analyzed using General Linear Models Procedure Adapted by SPSS (1997) for User's Guide, (one way ANOVA Model). Where appropriate means were separted using Duncnas multiple range tests (Duncan, 1955).

RESULTS AND DISCUSSION

Data in Table (2) show that cows fed protected fat ration (G_2) had significantly ($P < 0.05$) higher digestibility coefficients of DM, OM, CF EE, NFE and TDN value followed by cows fed ration supplemented with oil (G_3); while the control cows had the lowest values. Cows in G_3 had recorded the highest digestibility coefficient of CP and subsequently DCP value followed by the cows in G_2 and G_1, respectively. These results cleared that protected fat as well as oil supplementation in the experimental ration of dairy cows improved the digestibility and nutritive values of the ration. In this respect, Chouinard *et al.* (1998) found that the addition of protected fat in the ration of Holestein dairy cows improved nutrients digestibilities and nutritive values. Also, El-Bedawy (1995) reported that fat supplemetnation eighter form oil or Ca-soap led to significantly increase EE digestibility from 70 to 90%, which could be due to the high digestibility of fatty acids in the supplementary fat ration.

Table (2): Average digestibility coefficients, nutritive values and rumen activity in lactating Friesian cows feed different rations.

Item	Experimental group			SEM
	(G_1)	(G_2)	(G_3)	
Digestibility coefficients				
Dry matter (DM)	62.38^{c}	68.51^{a}	65.34^{b}	0.68
Organic matter (OM)	65.76^{c}	71.88^{a}	68.53^{b}	0.69
Crude protein (CP)	61.56^{b}	65.29^{a}	65.99^{a}	0.62
Crude fiber (CF)	59.47^{b}	64.88^{a}	60.24^{b}	0.94
Ether extract (EE)	63.80^{c}	83.18^{a}	77.03^{b}	2.27
Nitrogen free extract (NFE)	68.85^{c}	74.54^{a}	71.10^{b}	0.69
Nutritive value (%)				
TDN	60.30^{c}	68.78^{a}	66.24^{b}	0.97
DCP	7.79^{b}	7.94^{ab}	8.03^{a}	0.05
Rumen activity				
pH value	6.51	6.51	6.46	0.06
VFA's (mM/L)	20.86^{a}	18.34^{b}	18.90^{b}	0.70
Ammonia (mg %)	15.11^{a}	13.77^{b}	11.88^{c}	0.94

a, b and c: Value in the same row with different superscripts differ significantly ($P < 0.05$).
G1: control, G2 & G3: supplemented with protected fat and oil, respectively.

In contrast, ruminal pH value was not affected by fat or oil supplementation. These results agreed with those obtained by Chalupa *et al.* (1986). In the same time, the concentrations of TVFA's and ammmonia-N in the ruminal liquor of the cows fed supplemental fat or oil were significantly lower compared with that in control cows. These results might be attributed to the fact that fat supplementation reduced the degradability of protein by rumen microbial mainly at addition of oil to ration. These results are in agreement with those obtained by Tjarde *et al.* (1998), Onetti *et al.* (2001) and Demeterova *et al.* (2002), who reported that the addition of Ca-salt of fatty acid in ration of cows caused decrease concentration of VFA's and NH_3-N in rumen animals compared with cows fed ration without fat addition.

The differences in the concentrations of blood serum protein, albumin, globulin, urea and glucose were significant ($P<0.05$) among the different experimental groups. In this respect, the highest values were shown by the cows fed ration treated with palm oil, while the cows fed supplemental protected fat had the lowest value. The differences in total protein, albumin and globulin concentrations were not significant between G_1 and G_2 (Table, 3). These finding suggest that, supplementation of palm oil for the basal ration may increase the hepatic through an increase in synthesis of protein mainly albumin and globulin. This means that protected fat did not cause damage of liver. In addition, palm oil may increase glucose absorption. These results are in agreement with those obtained by Avila *et al.* (2000), Fahey *et al.* (2001)and Baraghit *et al.* (2003), who found that concentrations of blood total protein, albumin, globulin and glucose were higher in dairy cows and growing calves fed rations supplemented with protected fat. The increase in these parameters (Table 3) may reflect improvement of rumen fermentation, digestion rate and absorption (Kovacs *et al.*, 1998).

It clearly appears the protected fat and oil supplemented with ration significantly ($P < 0.05$) decrease in the concentration of blood serum urea. These results agree with those reported by Demeterova *et al.* (2002), who reported that blood urea level decreased significantly with protected fat supplementation in ration of dairy cows.

In addition, concentrations of serum protein, albumin and globulin were significantly ($P < 0.05$) affected by lactation period, while urea and glucose levels were not affected (Table, 3). However, these parameters were fluctuated during the experimental period, which may be due to milk production, reproductive hormones or other factors. Petit *et al.* (2001) and Francisco *et al.* (2002) reported that these parameters fluctuated from calving to lactation end and such fluctuation may be due to activity of rumen fermentation, level of milk production, nutrition, and reproductive hormones. Furthermore, Avila *et al.* (2000) and Salado *et al.* (2004) demonstrated that the changes in blood glucose may be due to change in insulin hormone during this period.

Data in Table (4) indicate that the overall mean of total blood serum lipids, triglycerides, cholesterol, HDL and LDL concentrations were significantly ($P < 0.05$) higher in G_2 and G_3 when compared with control group. Moreover, the cows fed the basal diet with palm oil had a significant higher lipids and HDL while the concentrations of triglycerides, total cholesterol and LDL were recorded the highest value in cows fed protected fat. An increase in these parameters for treated cows could be attributed to increased their absorption from the gut to the blood or to increase of hepatic function. These results are in accordance with those obtained by Khalaf *et al.* (1986), Sklan *et al.* (1989) and Selberg *et al.* (2004), who found that the concentrations of the respective parameters in blood serum or plasma of dairy cows increased with protected fat or palm oil supplementation in ration. The increase might be due to increasing fat absorption in the elementary tract (Selberg *et al.*, 2004).

Table (3): Effect of supplemented protected fat and oil on some blood constituents in lactating Friesian cows (Mean ± SE).

Experimental group	Lactation period (week)					Overall mean
	3	6	9	12	15	
Total protein (mg/dL)						
G_1	7.08±0.06^{Bb}	7.47±0.10^{Aa}	7.33±0.05^{Ba}	7.53±0.07^{Ba}	6.82±0.06^{Cc}	7.25±0.06^{B}
G_2	6.97±0.07^{Bb}	6.88±0.06^{Bb}	7.20±0.06^{Ba}	7.40±0.07^{Ba}	7.22±0.1^{Ba}	7.13±0.05^{B}
G_3	8.17±0.10^{Aa}	7.42±0.06^{Ac}	7.90±0.07^{Ab}	7.87±0.03^{Ab}	7.73±0.07^{Ab}	7.82±0.05^{A}
Overall mean	7.41±0.10^{ab}	7.26±0.08^{b}	7.48±0.08^{ab}	7.60±0.06^{a}	7.26±0.10^{b}	7.40±0.04
Albumin (mg/dL)						
G_1	4.03±0.04^{ABab}	4.05±0.04^{Aab}	3.97±0.07^{Bb}	4.15±0.04^{Aa}	3.52±0.05^{Bc}	3.94±0.05^{B}
G_2	3.90±0.06^{Bb}	3.73±0.05^{Bc}	4.08±0.03^{Ba}	3.90±0.06^{Bb}	4.02±0.06^{Aab}	3.93±0.03^{B}
G_3	4.20±0.07^{A}	4.13±0.04^{A}	4.28±0.06^{A}	4.18±0.06^{A}	4.18±0.07^{A}	4.20±0.03^{A}
Overall mean	4.04±0.04^{ab}	3.97±0.05^{ab}	4.11±0.04^{a}	4.08±0.04^{a}	3.91±0.08^{b}	4.02±0.02
Globulin (mg/dL)						
G_1	3.05±0.08^{Bb}	3.41±0.10^{a}	3.35±0.10^{ABa}	3.38±0.07^{Ba}	3.30±0.30^{ABab}	3.30±0.05^{B}
G_2	3.07±0.10^{Bb}	3.15±0.09^{b}	3.23±0.10^{Bab}	3.50±0.05^{ABa}	3.20±0.10^{Bb}	3.23±0.05^{B}
G_3	3.93±008^{Aa}	3.28±0.04d	3.62±0.09^{Abc}	3.68±0.08^{Ab}	3.45±0.07^{Ac}	3.59±0.05^{A}
Overall mean	3.35±0.10^{ab}	3.28±0.06^{b}	3.40±0.07^{ab}	3.52±0.05^{a}	3.32±0.05^{ab}	3.37±0.03
Urea (mg/dL)						
G_1	17.68±0.4^{Ba}	16.80±0.2^{Bab}	15.73±0.3^{Bb}	15.85±0.4^{Bb}	15.83±0.4^{Bb}	16.38±0.2^{B}
G_2	15.53±0.6^{Cab}	16.20±0.4^{Ba}	16.87±0.5^{Ba}	15.68±0.5^{Bab}	14.53±0.1^{Cb}	15.76±0.2^{C}
G_3	19.25±0.4^{A}	19.65±034^{A}	20.03±0.4^{A}	19.50±0.4^{A}	18.93±0.3^{A}	19.47±0.2^{A}
Overall mean	17.49±0.5	17.55±0.4	17.54±0.5	17.01±0.5	16.43±0.5	17.21±0.2
Glucose (mg/dL)						
G_1	67.33±0.3^{B}	67.38±0.2^{B}	67.43±0.2^{B}	67.45±0.2^{B}	67.43±0.2^{B}	67.41±0.1^{B}
G_2	63.50±0.8^{Cc}	64.38±0.4^{Cbc}	65.17±0.4^{Cbc}	66.40±0.7^{Ba}	65.57±1.0^{Bab}	65.40±0.4^{C}
G_3	70.62±0.4^{A}	70.90±0.3^{A}	71.18±0.3^{A}	71.38±0.4^{A}	71.55±0.8^{A}	71.13±0.2^{A}
Overall mean	67.15±0.8	67.56±0.7	67.93±0.6	68.40±0.6	68.85±0.7	67.98±0.3

a, b, c and A, B, C: Values within rows and columns, respectively for each character with different superscripts significantly differ ($P<0.05$)
G1: control, G2 & G3: supplemented with protected fat and oil, respectively.

Table (4): Effect of supplemented protected fat and oil on some blood serum constituents in lactating Friesian cows during early lactation period (Mean ± SE).

Experimental group	Lactation period (week)					Overall mean
	3	6	9	12	15	
Total lipids (mg/dL)						
G_1	404.0±1.4^{Ca}	370.0±6.3^{Cd}	524.0±3.6^{Ca}	456.5±7.6^{Cb}	461.67±5.2^{Cb}	443.23±10.1^{C}
G_2	376.2±11.5^{Bd}	472.0±5.8^{Bc}	553.8±6.7^{Bb}	555.8±3.6^{Bb}	611.50±4.0^{Ba}	513.87±15.5^{B}
G_3	420.83±5.9^{Ac}	533.5±7.3^{a}n^{d}	584.0±5.3^{Ac}	626.3±6.5^{Ab}	668.67±7.2^{Aa}	566.67±16.12^{a}
Overall mean	400.33±6.1^{c}	458.5±16.7^{b}	553.9±6.6^{a}	546.2±17.2^{a}	580.6±21.4^{a}	507.92±9.7
Triglycerides (mg/dL)						
G_1	27.28±0.8^{B}	27.87±0.4^{B}	27.25±0.6^{B}	27.45±0.4^{B}	27.52±0.4^{C}	27.47±0.2^{B}
G_2	39.08±0.8^{A}	39.80±0.7^{A}	40.23±0.4^{A}	39.00±0.7^{A}	40.48±0.2^{A}	39.72±0.3^{a}
G_3	39.27±0.2^{Aa}	39.10±0.3^{Aab}	39.53±0.2^{Aa}	39.03±0.2^{aab}	38.65±0.2^{Bb}	39.12±0.1^{A}
Overall mean	35.21±1.0	35.59±1.0	35.67±1.0	35.16±1.0	35.55±1.0	35.44±0.6
Total cholesterol (mg/dL)						
G_1	167.65±1.8^{Bc}	167.20±1.5^{Bc}	195.45±1.8^{Ba}	192.85±1.7^{Ba}	186.73±2.7^{Bb}	181.98±2.4^{B}
G_2	208.73±1.9^{a}	207.95±1.2^{a}	209.02±1.9^{A}	209.43±1.0^{A}	210.42±1.0^{A}	209.11±0.6^{A}
G_3	162.52±1.7^{B}	162.02±1.8^{C}	161.03±1.5^{C}	160.30±1.5^{C}	159.80±2.1^{C}	161.13±0.8^{C}
Overall mean	179.6±5.1	179.1±5.0	188.5±5.0	187.5±5.0	185.7±5.1	184.1±2.3
High density lipoprotein HDL (mg/dL)						
G_1	66.58±0.9^{C}	67.38±1.0^{C}	67.60±0.6^{C}	67.93±0.9^{C}	67.55±0.4^{C}	67.41±0.3^{C}
G_2	81.00±0.8^{Bb}	84.45±1.0^{Ba}	82.48±0.9^{Bab}	83.48±1.0^{Bab}	80.90±0.4^{Bb}	82.46±0.5^{B}
G_3	90.62±0.5^{A}	89.57±0.7^{A}	90.48±0.8^{A}	90.85±0.8^{A}	89.25±0.6^{A}	90.25±0.3^{A}
Overall mean	79.4±2.0	80.5±2.0	80.2±2.0	80.8±2.0	79.2±2.0	80.0±1.0
Low density lipoprotein LDL (mg/dL)						
G_1	97.28±3.8^{Bb}	94.20±1.8^{Bb}	121.07±2.0^{Aa}	119.43±2.0^{Aa}	113.70±2.8^{Ba}	109.14±2.4^{B}
G_2	119.93±2.4^{Aab}	115.57±0.6^{Ab}	118.53±1.0^{Aab}	118.08±1.6^{Aab}	121.50±1.1^{Aa}	118.72±0.7^{A}
G_3	63.85±1.7^{C}	64.57±2.1^{C}	62.72±2.0^{B}	61.63±1.6^{B}	62.82±2.2^{C}	63.12±0.8^{C}
Overall mean	93.69±6.0	91.44±5.0	100.77±7.0	99.72±7.0	99.34±6.0	96.99±2.7

a, b, c and A, B, C: Values within rows and columns; respectively for each character with different superscripts significantly differ ($P < 0.05$).

G1: control, G2 & G3: supplemented with protected fat and oil, respectively.

This cleared with the results in Table (2), whereas the cows fed fat supplementation had better the digestibilities coefficient and nutritive values.

The obtained data revealed that the lowest values were recorded at the start of the experiment and the highest values at the end of the experimental period. The corresponding balance changes may be due to changes in hormone and organs physiological function. These results are in agreement with those obtained by Thomas *et al.* (1997), who reported that these parameters increased gradually with progress of lactation period. An increase may be attributed to greater quantity of fatty acid absorbed from fat supplementation in rations (Graton, 1965) and/or the fact that feeding fat is associated with depression in lipogenic enzyme activities by liver and adipose tissue lead to increase synthesis of all components of lipids in blood (Steele, 1980).

Milk production expressed as actual milk yield and 4% fat corrected milk (FCM) were significantly ($P < 0.05$) greater for cows fed supplemented ration with either protected fat or palm oil for cows fed control ration (Table 5). These results could be attributed to increasing energy content of the treated rations by fat supplementation and due to improve the nutritive values of supplemented rations as shown in Table (2). Milk yield increased in G_2 and G_3 by 5.76 and 4.3 kg/day, while FCM increased by 4.97 and 4.15 kg/day, respectively when compared with animals in G_1. Moreover, these results are in agreement with those obtained by Garbswortuy (1996) and Moallem *et al.* (1997), who found that the actual milk yield and fat corrected milk response to fat supplementation were significantly higher compared to the control group. Moreover, Petit *et al.* (2001) reported that milk production was greater for cows fed protected fat than those fed protected oil.

Furthermore, milk production progressively increased after calving reaching the peak production at 4-8 weeks of the lactation and afterwards it decreased progressively reaching its minimum level at the 14^{th} week of lactation (Table 5). These results are similar with those reported by Valdez *et al.* (1988), who suggested that changes in milk yield and its contents during early lactation period may be due to changes in the level of prolactin hormone secretion, efficiency of the udder secretory cells and some other metabolic factors.

Yields of fat, protein, lactose, total solids and solids not fat in milk of cows fed ration supplemented with protected fat increased by 34.62, 37.84, 36.36, 36.30 and 37.17%, while cows treated with palm oil increased by 30.77, 29.73, 28.79, 29.70 and 29.20%, respectively in comparing with cows fed ration without supplementation (Table, 6). The same trend was repoted by Bayourthe *et al.* (2000), Benson *et al.* (2001) and Reksen *et al.* (2002), who found that yields of milk contents increased significantly in dairy cows fed rations supplemented with either protected fat or palm oil as compared to unsupplemented. An increase in these contents may be due to improve the ruminal microbes in treated cows and improve efficiency both gut and udder in absorption to and from blood, respectively (Drackley and Elloitt, 1993 and Benson *et al.*, 2001).

Table (5): Effect of supplemented protected fat and oil on daily milk yield and fat corrected milk yield for lactating Friesian cows (Mean ± SE).

Experimental group	Lactation period (week)							Overall mean
	2	4	6	8	10	12	14	
Milk yield (kg/d)								
G_1	12.70±0.70^{Bb}	16.94±1.1^{Ba}	17.04±0.7^{Ba}	17.60±0.9^{Ba}	15.30±1.0^{Bab}	13.74±1.3^{Bb}	13.73±1.2^{Bb}	15.30±0.5^{C}
G_2	18.76±0.6^{ad}	22.92±0.8^{Aab}	23.26±0.5^{Aa}	22.70±0.7^{Aab}	21.29±0.6^{Abc}	19.82±0.6^{Acd}	18.61±0.45^{Ad}	21.06±0.4^{A}
G_3	18.95±1.0^{Abc}	21.95±0.9^{Aa}	22.25±0.6^{Aa}	20.41±1.0^{Aab}	19.02±0.95^{Abc}	17.91±0.95^{Abc}	16.70±096^{Abc}	19.60±0.4^{B}
Overall mean	16.80±0.8^{b}	20.60±0.8^{a}	20.85±0.7^{a}	20.26±0.7^{a}	18.53±0.8^{ab}	17.20±0.8^{b}	16.34±0.7^{b}	18.65±0.3
4% Fat corrected milk (kg/d)								
G_1	11.27±0.6^{Bb}	15.90±1.6^{Ba}	14.60±1.0^{Bab}	15.84±1.4^{a}	13.82±1.1^{Bab}	11.83±0.63^{Bb}	14.43±1.2^{ab}	13.95±0.5^{B}
G_2	18.60±1.0^{a}	20.47±1.3^{a}	19.33±0.9^{a}	19.01±1.1	19.21±1.1^{a}	18.19±0.9^{A}	17.65±0.9	18.92±0.4^{A}
G_3	19.28±1.3^{Aabc}	20.41±1.3^{aa}	19.90±1.2^{Aab}	16.64±0.81^{bc}	17.09±0.99^{Abc}	16.32±0.6^{Ac}	16.89±1.2^{bc}	18.1±0.5^{A}
Overall mean	16.38±1.0^{ab}	18.92±0.9^{a}	17.93±0.8^{ab}	17.17±0.7^{ab}	16.71±0.8^{ab}	15.45±0.8^{b}	16.33±0.7^{ab}	16.98±0.3

a, b, c and A, B; C: Values within rows and columns; respectively for each character, with different superscripts are significantly differ ($P < 0.05$).

G1: control, G2 & G3: supplemented with protected fat and oil, respectively.

Table (6): Effect of supplemented protected fat and oil on some milk yields for lactating Friesian cows (Mean ± SE).

Experimental group	Lactation period (week) 2	4	6	8	10	12	14	Overall mean
Fat yield (kg/d)								
G_1	0.41±0.04^{Bc}	0.61±0.08^{a}	0.52±0.05^{Babc}	0.59±0.08^{ab}	0.51±0.05^{Babc}	0.42±0.03^{Bbc}	0.60±0.05^{a}	0.52±0.02^{B}
G_2	0.74±0.06^{A}	0.75±0.07	0.67±0.06^{AB}	0.66±0.06	0.71±0.06^{A}	0.68±0.05^{a}	0.68±0.05	0.70±0.02^{A}
G_3	0.78±0.07^{Aa}	0.78±0.07^{a}	0.73±0.08^{Aab}	0.57±0.04^{b}	0.63±0.05^{abab}	0.61±0.03^{aab}	0.68±0.05^{ab}	0.68±0.02^{A}
Overall mean	0.64±0.05^{ab}	0.71±0.04^{a}	0.64±0.04^{ab}	0.60±0.03^{ab}	0.62±0.03^{ab}	0.57±0.03^{b}	0.65±0.03^{ab}	0.64±0.015
Protein yield (kg/d)								
G_1	0.28±0.04^{Bb}	0.41±0.05^{Ba}	0.38±0.03^{Bab}	0.43±0.03^{a}	0.36±0.01^{Bab}	0.32±0.03^{Bab}	0.39±0.06^{ab}	0.37±0.02^{B}
G_2	0.54±0.09^{Aab}	0.54±0.03^{aab}	0.58±0.06^{Aa}	0.47±0.03^{ab}	0.49±0.03^{Aab}	0.52±0.03^{Aab}	0.42±0.03^{b}	0.51±0.02^{A}
G_3	0.42±0.04^{abc}	0.52±0.02^{Aab}	0.57±0.02^{Aa}	0.47±0.02^{bc}	0.44±0.05^{abbc}	0.46±0.01^{Abc}	0.44±0.02^{bc}	0.48±0.01^{A}
Overall mean	0.41±0.04^{b}	0.49±0.03^{ab}	0.51±0.03^{a}	0.46±0.02^{ab}	0.43±0.02^{ab}	0.43±0.03^{ab}	0.42±0.02^{b}	0.45±0.01
Lactose yield (kg/d)								
G_1	0.53±0.03^{Bc}	0.74±0.07^{Ba}	0.74±0.03^{Ba}	0.77±0.04^{Ba}	0.70±0.05^{Bab}	0.53±0.03^{Bc}	0.59±0.06^{Bbc}	0.66±0.02^{B}
G_2	0.76±0.06^{Ac}	0.99±0.07^{Aa}	1.01±0.03^{Aa}	1.01±0.04^{Aa}	0.92±0.03^{Aab}	0.83±0.02^{Abc}	0.79±0.04^{Abc}	0.90±0.02^{A}
G_3	0.79±0.04^{Abc}	0.94±0.04^{Aa}	0.96±0.04^{Aa}	0.91±0.04^{Aab}	0.83±0.05^{Aabc}	0.76±0.04^{Ac}	0.72±0.05^{abc}	0.85±0.02^{A}
Overall mean	0.70±0.04^{b}	0.89±0.04^{a}	0.90±0.03^{a}	0.90±0.03^{a}	0.82±0.03^{a}	0.71±0.04^{b}	0.70±0.03^{b}	0.80±0.015
Total solids yield (kg/d)								
G_1	1.31±0.07^{Bb}	1.87±0.2^{Ba}	1.76±0.08^{Ba}	1.91±0.1^{Ba}	1.68±0.1^{Bab}	1.36±0.08^{Bb}	1.67±0.2^{ab}	1.65±0.06^{B}
G_2	2.16±0.08^{Aab}	2.44±0.2^{Aa}	2.38±0.1^{Aa}	2.30±0.09^{Aab}	2.27±0.1^{Aab}	2.17±0.1^{Aab}	2.02±0.09^{b}	2.25±0.04^{A}
G_3	2.12±0.09^{Ab}	2.40±0.1^{Aa}	2.42±0.07^{Aa}	2.10±0.08^{abb}	2.04±0.1^{Ab}	1.95±0.06^{ab}	1.95±0.1^{b}	2.14±0.04^{A}
Overall mean	1.87±0.1^{b}	2.24±0.1^{a}	2.20±0.09^{a}	2.10±0.07^{ab}	2.00±0.08^{ab}	1.83±0.09^{b}	1.88±0.08^{b}	2.10±0.04
Solids not fat yield kg/d)								
G_1	0.90±0.07^{Bc}	1.30±0.3^{Ba}	1.24±0.1^{Ba}	1.32±0.2^{Ba}	1.17±0.2^{Bab}	0.93±0.2^{Bbc}	1.07±0.1^{abc}	1.13±0.04^{c}
G_2	1.42±0.07^{Acd}	1.69±0.1^{Aab}	1.71±0.05^{Aa}	1.63±0.05^{Aab}	1.56±0.05^{Aabc}	1.49±0.06^{Abcd}	1.34±0.06^{d}	1.55±0.03^{A}
G_3	1.34±0.06^{Ac}	1.62±0.06^{Aa}	1.69±0.04^{Aa}	1.53±0.06^{Aab}	1.41±0.08^{Abc}	1.34±0.05^{Ac}	1.27±0.06^{c}	1.46±0.03^{B}
Overall mean	1.22±0.07^{b}	1.53±0.07^{a}	1.55±0.06^{a}	1.49±0.05^{a}	1.38±0.05^{ab}	1.26±0.06^{b}	1.23±0.06^{b}	1.38±0.03

a, b, c, d and A, B, C: Values within rows and columns; respectively for each character with different superscripts are significantly differ ($P < 0.05$).

G1: control, G2 & G3: supplemented with protected fat and oil, respectively.

Other studies found that protected fat or palm oil had no effect on milk composition, but significantly affected its yield (Bayourthe *et al.*, 2000 and Petit *et al.*, 2001).

On the other hand, yields of milk components were significantly ($P < 0.05$) affected by lactation period, whereas they reached the maximum value between the 4^{th} and 8^{th} weeks postpartum and then gradually decreased. These results are in agreement with those reported by Spicer *et al.* (2000) and Francisco *et al.* (2002). Changes in these contents during early lactation period may be due to the change in the hormonal status efficiency of the udder, type of the nutrition and some other factors (Chouinard *et al.*, 1998).

The lactating Friesian cows fed ration supplemented with palm oil had shorter period to express the first estrous after calving and longer period of days open. While, the cows in G_1 had shorter period to days open. Moreover, number of insemination per conception was more than and equal in G_1 and G_3 compared with that in G_2 (Table, 7). It clearly appears that the differences in number of insemination per conception and day open length among the different groups were not significant. However, the cows fed ration treated with protected fat or palm oil had longer days open and this may be due to the increase in milk production, which would delay pregnancy.

These results are in agreement with these obtained by Moallem *et al.* (1997) and Thatcher *et al.* (1999), who found that cows fed protected fat or oil had longer days open when compared with cows fed ration without additives. This may be due to delay in resumption of ovarian cyclicity and disappearance of behavioral symptoms of estrus in Ca-salt of fatty acids fed cows (Butler and Smith, 1989).

Moreover, conception rate after the 3^{rd} insemination within 150 days postpartum was higher in G_3 (100%), while the cows in both G_1 and G_2 were similar (66.8%). In this respect, Thatcher *et al.* (1999) reported that reproductive hormones in blood plasma are enhanced by fat or oil supplementation, possibly by stimulating the synthesis of its precursor (cholesterol) whereas an increase inspection of these hormones may be enhance conception and embryo survival.

Data in Table (8) show that the amounts of DM, TDN and DCP intake required to produce 1 kg 4% FCM for cows given control ration were significantly ($P < 0.05$) higher than that for cows fed protected fat or oil. These results revealed that protected fat and palm oil supplementation improved feed efficiency of lactating Friesian cows and in the same time agree with the results in Table (2). Moreover, supplementation of protected fat and palm oil led to reduce their demanded of DM, TDN and DCP to milk production. These results are in agreement with those obtained by Omer (1999), who found that Ca-salts of fatty acids supplementation in ration of Friesian calves improved feed efficiency.

The present results show that cows fed supplemental protected fat and palm oil had greater economic efficiency by 35.59 an 29.71% than cows given control ration, respectively. These results could be attributed to the higher milk yield and lower intake of DM, TDN and DCP for cows treated with fat and oil.

Table (7): Effect of supplemented protected fat and oil on reproductive performance in lactating Friesian cows.

Item	Experimental group			Overall mean
	G_1	G_2	G_3	
Interval from calving to first estrus (day)	67.83±11.0^{a}	69.00±8.5^{a}	40.67±3.6^{b}	59.17±5.5
Interval from first estrus to conception (day)	24.75±5.5^{b}	33.0±15.0^{ab}	68.0±13.0^{a}	45.64±8.6
Days open (day)	92.58±9.8	102.00±2.00	108.67±12.4	99.93±8.3
Number of insemination/conception	2.5±0.4	2.00±0.2	2.5±0.3	2.33±0.20
Conception rate (%) at the:				
First service	(0/6) 0.00±0.00	(1/6) 16.67±16.7	(0/6) 0.00±0.00	5.56±5.56
Second service	(4/6) 66.67±21.1	(2/5) 40.00±24.5	(3/6) 50.0±22.4	52.9±12.5
Third service	(0/2) 0.00±0.00^{b}	(1/3) 33.33±33.3^{ab}	(3/3) 100.00^{a}	50.9±18.9
Conception rate from the 1st, 2nd, 3rd insem.	(4/6) 66.67±21.1^{b}	(4/6) 66.67±21.1^{b}	(6/6) 100.00±0.0^{a}	77.8±10.08
Conception rate % at:				
Day 90	(2/6) 33.33±21.1	(2/6) 33.33±21.1	(2/6) 33.33±21.1	33.33±11.43
Day 120	(4/6) 66.67±28.9^{a}	((2/6) 33.33±21.1^{b}	(3/6) 50.00±25.0^{ab}	50.00±13.06
Day 150	(4/6) 66.67±28.9^{b}	(4/6) 66.67±28.9^{b}	(6/6) 100.00^{a}	77.78±17.6

a, b and c: Values in the same row with different superscripts are significantly differ ($P < 0.05$).
G1: control, G2 & G3: supplemented with protected fat and oil, respectively.

These results agreed with those obtained by Omer (1999), who found that Friesian calves fed ration supplemented with Ca-salts fatty acids had better in economic efficiency.

Table (8): Feed and economic efficiency of lactating cows fed the experimental rations.

Item	Experimental group			
	G1	G2	G3	SEM
Feed efficiency				
DM intake kg/kg FCM	1.29[a]	0.90[b]	0.90[b]	0.05
TDN intake kg/kg FCM	0.78[a]	0.62[b]	0.60[b]	0.05
DCP intake g/kg FCM	100.36[a]	71.35[b]	72.38[b]	3.07
Economic efficiency				
Feed cost (LE/day)	9.74[b]	10.33[a]	9.42[c]	
Output of FCM (LE day)	15.35[b]	20.81[a]	19.91[a]	
Economic efficiency	100.00[b]	135.59[a]	129.71[a]	

a, b and c: Values in the same row with different superscripts differ significantly ($P < 0.05$).

G1: control, G2 & G3: supplemented with protected fat and oil, respectively.

It can be concluded that addition of protected fat or palm oil for rations of lactation cows lead to improve digestibility coefficients, nutritive values and metabolic blood which lead to increase milk production and total solids in milk. Moreover, supplementation of fat and oil lead to prove reproductive performance although an increasing in their production. Also, a result of these factors cost of one kg of milk decreased and income from treated animals increased.

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تأثير إضافة الدهون على الأداء الإنتاجى والتناسلى فى أبقار الفريزيان الحلابة خلال المرحلة الأولى من الحليب

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استخدم فى هذه الدراسة ثمانية عشر بقرة فريزيان حلابة قسمت إلى ثلاث مجموعات الأولى غذيت على العليقة الأساسية وكانت كمجموعة مقارنة ، والثانية والثالثة استبدل ٣% من العليقة المركزة بدهن محمى أو زيت النخيل (الاستيارين) على التوالى. وذلك لدراسة تأثيرهما على القيمة الغذائية وتخمرات الكرش ومكونات الدم وإنتاج اللبن والكفاءة التناسلية مع دراسة القيمة الاقتصادية لتلك الإضافات وقد استمرت الدراسة من الأسبوع الأول وحتى الاسبوع الخامس عشر من بعد الولادة.

أظهرت الأبقار التى غذيت على الدهن المحمى وزيت النخيل تحسن فى معاملات الهضم بصورة معنوية وترتب على ذلك تحسن فى القيمة الغذائية لتلك العلائق عند مقارنتها بمجموعة المقارنة ، بينما لم تتأثر معنويا قيم رقم الحموضة والأحماض الدهنية الطيارة فى الكرش بين المجموعات المختلفة.

وبالنسبه لسيرم الدم وجد أن البروتين الكلى والألبيومين والجلوبيولين والليبيدات الكلية والليبوبروتين عالى الكثافة كانت مرتفعة معنويا فى المجموعة الثالثة ، بينما فى المجموعة الثانية سجل الكوليسترول والليبوبروتين المنخفض الكثافة والجليسريدات الثلاثية اعلى القيم وذلك عند مقارنتها بالمجموعات الأخرى.

سجلت الأبقار التى غذيت على الدهن المحمى (المجموعة الثانية) أعلى كمية من انتاج اللبن وكذلك من اللبن المعدل ٤% دهن وتلتها المجموعة الثالثة ، بينما كان اقل مستوى مسجل فى مجموعة المقارنة (الأولى) ، كما تم حساب كميات الدهن والبروتين واللاكتوز والمواد الصلبة الكلية والمواد الصلبة الغير دهنية فى اللبن. وقد وجد أنها اخذت نفس اتجاه كمية اللبن فى المجموعات الثلاث، بالنسبة للكفاءة التناسلية وجد أن الفترة من الولادة وحتى الحمل (التلقيح المخصب) كانت أطول فى المجموعة الثالثة تلتها الثانية بينما الأولى كانت أقصر المجموعات كما قل عدد التلقيحات اللازمة لحدوث الإخصاب (٢) فى المجموعة الثانية مقابل ٢,٥ فى الأولى والثالثة ولكن الفرق غير معنوى، وقد سجل أعلى معدل إخصاب خلال ١٥٠ يوم بعد الولادة فى المجموعة الثالثة عند مقارنتها بالمجموعات الأخرى.

كما أشارت الدراسة إلى أن إضافة الدهون المحمية أو زيت النخيل إلى علائق الأبقار الفريزيان الحلابة يؤدى إلى تحسين كفاءتها الغذائية مع انخفاض الكمية اللازمة من المادة الجافة والمركبات الكلية المهضومة والبروتين المهضوم اللازمة لإنتاج واحد كليوجرام لبن (% دهن) ، وأن العائد الاقتصادى من انتاج اللبن زاد بصورة معنوية نتيجة المعاملة.

من هذه الدراسة يتضح أن اضافة تلك المركبات الدهنية الى علائق الابقار الفريزيان الحلابة عقب الولادة ذات أهمية اقتصادية فى تحسين انتاج اللبن والكفاءة التناسلية.