

## SOME PRODUCTIVE AND PHYSIOLOGICAL RESPONSES OF LACTATING EGYPTIAN BUFFALOES AS AFFECTED BY DIETARY SUPPLEMENTATION OF PROTECTED FAT

A.K.I. Abd-El Moty, E.B. Soliman, S.T.M. Fahmy and E.M. Ibrahim

Animal Production Department, Faculty of Agriculture, El-Minia University, El-Minia, Egypt

### SUMMARY

Six multiparous lactating Egyptian buffaloes in their second and fourth season of lactation after their peak of milk production were used in two complete balanced period's changeover design experiment during January to March. Three experimental rations (T1, T2 and T3) were fed in amounts to meet 100, 110 and 115 % of their AFRC (1993) metabolizable energy (ME) requirements. The protected fat (calcium salts of palm oil fatty acids) was added daily and mixed with the concentrate mixture in T2 and T3. All concentrate mixtures were iso-nitrogenous. Sugarcane bagasse was offered ad libitum as a roughage source. Protected fat supplementation increased ( $P<0.05$ ) milk yield, 7% FCM, milk fat yield and total dry matter intake. The rectal temperature decreased ( $P<0.05$ ) at 8.00 am and 2.00 pm for buffaloes fed protected fat supplemented rations (T2 and T3) compared with those fed the control ration (T1). However, fat supplementation had no effect on respiration rate at 8.00 am however, decreased ( $P<0.05$ ) at 2.00 pm for buffaloes fed T2 and T3 compared with those fed T1. Blood hemoglobin increased ( $P<0.05$ ) for buffaloes fed on T2 and T3 when compared with those fed T1 ration. Protected fat supplementation led to an increase ( $P<0.05$ ) in packed cell volume, red blood cell counts, white blood cell counts and corpuscular hemoglobin and corpuscular volume. However, the values of corpuscular hemoglobin concentration did not change due to fat supplementation. The concentrations of plasma glucose, total protein, albumin and globulin increased ( $P<0.05$ ) for buffaloes fed T2 and T3 compared with those fed T1. Also, concentrations of plasma total lipids, cholesterol and triglycerides were higher ( $P<0.05$ ) for buffaloes fed T2 and T3 than those fed T1. Also, the concentrations of triiodothyronine and thyroxin were higher ( $P<0.05$ ) for buffaloes fed T2 and T3 than those fed T1. This study indicated that protected fat supplementation in lactating buffaloes can be improved some of their productive and physiological responses, indicating that the efficient metabolic activities of these animals were enhanced.

**Keywords:** Productive and physiological responses, lactating buffaloes, supplemental protected fat

### INTRODUCTION

Buffalo's milk contributes about 73 % of the total milk production in Egypt (Abou-Hussein *et al.*, 2003). Calcium salts of palm oil fatty acids permit the total dietary fatty acid digestibility to be high compared to other fat supplements (Block *et al.*, 2005). Thus, supplementing the ration of lactating cows with calcium salts of palm oil fatty acid can improve the milk production as well as milk quality (Purushothaman *et al.*, 2008). Buffalo's productivity is affected by many factors. Some of these are nutritional, genetical, hygienic, physiological, *etc.* Physiological reactions such as body temperature and respiration rate in response to fat supplementation were studied by many investigators (Soliman *et al.*, 2001; Moallem *et al.*, 2010; Wang *et al.*, 2010; Zhang *et al.*, 2011). Moreover, utilization of supplemental fat in cow rations has been described to positively or adversely affect hematological parameters (Rajora *et al.*, 1997; Omer, 1999; and Awad, 2001), and blood metabolites (Marreck, 1996; El-Shewy, 1997; Bremmer *et al.*, 1998; and Petit *et al.*, 2004).

The objective of this study was to determine the effect of dietary protected fat (calcium salts of palm oil fatty acids) supplementation on some productive performances and physiological responses such as thermal responses, hematological characteristics as well as some blood metabolites and hormones levels of lactating Egyptian buffaloes.

### MATERIAL AND METHODS

#### *Animals and experimental design:*

The present study was carried out at the farm of Animal Production Department, Faculty of Agriculture, El-Minia University. Six lactating Egyptian buffaloes of  $561.0\pm 33.0$  kg body weight in second to fourth parity after the peak of milk production were used during January to March in a two complete balanced periods changeover experimental design (Gill and Magee, 1976). The experiment consisted of two periods. The animals were fed the tested dietary treatments for 28 days in each period (21 days for adaptation and 7 days for milk and blood samples collection). At the end of the

first experimental period, the buffaloes were reassigned to the experimental diets for another 28 days period (the second experimental period). Along the experiment, each animal received two different dietary treatments and each diet was tested on four animals. Three experimental rations (T1, T2 and T3) were formulated to meet 100, 110 and 115 % of the buffaloes metabolizable energy requirements for maintenance and production calculated according to AFRC (1993) recommendations for dairy cattle. The control concentrate mixture in the first treatment (T1) contained 43.25 % uncorticated cotton seed meal, 29.5 % wheat bran, 11 % molasses, 8.75 % yellow corn, 3.75 % rice bran, 2.5 % calcium carbonate and 1.25 % sodium chloride. Protected fat (calcium salts of palm oil fatty acids, Megalac®) was added daily to the concentrate mixture of T2 and T3. To achieve the 10 and 15 % of the metabolizable energy requirements, the calcium salts of palm fatty acids represented 2.00 and 3.06 % of the whole ration. The dietary treatments contain 11.23, 12.35 and 12.92 MJ ME / kg DM for T1, T2 and T3, respectively. All concentrate mixtures were iso-nitrogenous and provide 172.5 g crude protein/kg DM (91.44 g metabolizable protein/kg DM), according to the tabulated values for each ingredient (AFRC, 1993). Sugarcane bagasse was offered *ad libitum* as a roughage source. During the experimental periods, a commercial mineral mixture was mixed with the concentrate mixture (1 kg/ton). In addition, vitamins A, D3, E and C requirements were injected biweekly according to the NRC requirements (NRC, 2001). Animals were housed and fed in stables for individually. Fresh water was available along the experiment. Buffaloes were subjected to the routinely veterinary vaccination and inspection system.

#### **Milk sampling and measurements:**

Milk yield per each animal was recorded daily and milk samples (10 ml/kg milk produced) from morning and afternoon milking were collected on days 24 and 27 of each period. Milk fat was measured by Gerber units (British Standard Institution, 1962). Total dry matter intake (TDMI, kg/h/d) was calculated.

At the last week of each experimental period, thermal responses (rectal temperature, (RT °C) and respiration rate, (RR, r.p.m) of each experimental lactating buffalo were recorded twice a day at 8.00 am and 2.00 pm on days 24 and 27 of each period. Rectal temperature was recorded using clinical mercury thermometer inserted into the rectum for two minutes. Respiration rate was determined by counting the flank's movements

per minute. Ambient temperature (AT, °C) and relative humidity (RH, %) were recorded at time of RT and RR measurements. Ambient temperature was measured using a thermometer hanged at a level of about two meters above the floor and the RH was recorded using a psychrometer. The averages of AT and RH during the experimental periods were 14.21°C, 39.56% at 8.00 am and 24.5°C, 30.75% at 2.00 pm, respectively.

#### **Blood sampling and measurements:**

At the end of each period, heparinized blood samples were collected from the jugular vein of each animal at 8.00 am before feeding or watering. Whole blood samples were analyzed after collection for hemoglobin (Hb, gm/dl), packed cell volume (PCV, %), red blood cell counts (RBCs,  $\times 10^6 / \text{mm}^3$ ) and white blood cell counts (WBCs,  $\times 10^3 / \text{mm}^3$ ). The Hb concentration was determined by Shali's method. The PCV was determined using microhematocrite tubes with a microhematocrite centrifuge at 12000 r.p.m for three minutes. The RBCs and WBCs were counted using the light microscope. Mean corpuscular hemoglobin concentration [MCHC = (Hb in gm/dl) / PCV (%)  $\times 100$ ], mean corpuscular volume [MCV = (PCV in a liter) / RBCs in ml/mm<sup>3</sup>] and mean corpuscular hemoglobin [MCH = (Hb in gm/liter blood) / (RBCs in ml/mm<sup>3</sup>)] were calculated using the formulas proposed by Schalm (1965).

Plasma samples were collected by centrifugation of heparinized blood samples at 3000 r.p.m for 10 minutes. Blood plasma was kept frozen at -20 °C for later analysis. Plasma triiodothyronine and thyroxin concentrations were determined by a direct solid-phase I<sup>125</sup> radioimmunoassay techniques using (coat-A-count TKT<sub>3</sub> and TKT<sub>4</sub>) RIA Kits purchased from Diagnostic Products Corporation (DPC, Los Angeles, CA, 90045-5597, USA). Thyroxin/triiodothyronine ratio was calculated. Plasma glucose (mg/dl), cholesterol (mg/dl) and triglycerides (mg/dl) were determined using Bio-Merieux Kits (marcy-1, Etolie Charbnnieres-Les-Bains, France). Plasma total protein (g/dl), albumin (g/dl) and total lipids (mg/dl) were determined using Bio-Analytics Kits (USA), however plasma globulin concentrations were calculated by difference between total protein and albumin concentrations.

#### **Statistical analysis:**

Duncan's multiple rang test (Duncan, 1955) was used to determine the significance among treatment means using the GLM procedure of SAS (1990) for a completely two period changeover design (Gill and Magee, 1976) according to the linear model:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + T_k + E_{ijk}$$

Where,

$\mu$  = The overall mean,

$\alpha$  = The random effect of buffaloes ( $i = 1, \dots, 6$ ),

$\beta$  = The fixed effect of experimental periods  $j = 1, 2$ ,

T = The fixed effect of dietary treatments ( $k = 1, \dots, 3$ ) and

E = The experimental error ( $O, \delta^2$ ).

## RESULTS

### *Some productive performances:*

The results of milk yield, 7 % FCM, milk fat yield and total dry matter intake are presented in Table (1). Values of milk yield were greater ( $P < 0.05$ ) for buffaloes of T2 and T3 than those of T1, by 18.9 and 35.8%, respectively. Also, milk yield increased ( $P < 0.05$ ) by 14.2% in T3 group compared with T2. The yields of 7% FCM were higher ( $P < 0.05$ ) for buffaloes of T2 and T3 than those of T1. The increases in 7% FCM were 25.78 and 52.75% in T2 and T3 compared with T1. Milk fat yield was higher ( $P < 0.05$ ) for buffaloes fed T2 and T3 than those fed ration of T1. These increases in milk fat yield were calculated to be 28.1 and 58.6% T2 and T3 more than control one. The values of total dry matter intake (TDMI) were increased ( $P < 0.05$ ) by 7.8 and 17.8% for buffaloes fed rations T2 and T3 when they compared with those fed T1, respectively. The calculated efficiency of FCM production per kg TDMI was higher ( $P < 0.05$ ) by 18.0 and 30.0 % for buffaloes fed T2 and T3 than those fed the control ration of T1.

### *Thermal responses:*

Data presented in Table (2), showed the effect of protected fat supplementation on rectal temperature (RT, °C) of lactating buffaloes. These results revealed that RT decreased ( $P < 0.05$ ) by 1.03 and 1.43 % at 8.00 am and by 1.12 and 1.67 % at 2.00 pm when buffaloes were fed T2 and T3 as compared with T1. There was no significant difference in RT among buffaloes fed rations T2 and T3. Data of respiration rate (RR, r.p.m) showed that there was no significant difference among the three experimental rations at 8.00 am. However, there was a significant ( $P < 0.05$ ) decrease in the values of RR at 2 pm by 15.12 and 18.91 % for buffaloes fed rations T2 and T3 comparing to control ration (T1). No significant difference was detected between buffaloes fed rations T2 and T3.

### *Hematological parameters:*

Data in Table (3) indicated that the values of hemoglobin (Hb) increased ( $P < 0.05$ ) by 13.00 and 22.54 % for buffaloes fed rations of T2 and T3 compared with control ration group

(T1). However, Hb values increased by 8.44 % when T3 was compared with T2, but the differences were not significant. Also, the results indicated that the percentage of PCV increased ( $P < 0.05$ ) by 12.70 and 20.63 % for buffaloes fed rations T2 and T3, respectively when compared with control ration. However, there was no significant difference in PCV percentage among buffaloes fed rations T2 and T3. As shown in Table (3), blood cell count's (RBC's and WBC's) increased ( $P < 0.05$ ) by 5.34 and 9.96 % for RBC's and 3.34 and 6.20 % for WBC's due to feeding T2 and T3, respectively in comparison with T1. The results revealed that the calculated hematological parameters such as corpuscular hemoglobin, corpuscular volume increased ( $P < 0.05$ ) when T2 or T3 were fed in comparison with T1, by 7.24 and 8.68% for MCH; 6.66 and 9.69 % for MCV, respectively. However, the values of corpuscular hemoglobin concentration were not significantly affected as a result of protected fat supplementation.

### *Plasma metabolites:*

Buffaloes fed T2 and T3 had higher ( $P < 0.05$ ) values of plasma glucose than those fed T1 ration by 15.97 and 26.05%, respectively more than T1 group. Plasma glucose concentrations also increased ( $P < 0.05$ ) by 8.70 % for buffaloes fed T3 compared to T2 (Table 4). Also, the results indicated that the averages of total protein concentrations increased ( $P < 0.05$ ) by 4.94 and 9.04 % for buffaloes fed T2 and T3, respectively compared with T1. There was no significant difference in plasma total protein among buffaloes fed ration T2 and T3. Also data showed that plasma albumin was greater ( $P < 0.05$ ) for buffaloes fed rations T2 and T3 than those fed ration T1 by 7.89 and 8.68% for buffaloes fed T2 and T3, respectively relative to T1. No significant difference in plasma albumin concentration was observed among buffaloes fed rations T2 and T3. Data of plasma globulin showed that there was significant ( $P < 0.05$ ) increases by 9.78 and 8.1% for buffaloes fed T3 when compared to those fed T1 and T2, respectively. Ratios of Albumin/Globulin were not significantly different among the three rations. Data in Table (4) revealed that protected fat supplementation had positive ( $P < 0.05$ ) effect on plasma total lipids. The determined values were higher by 17.75 and 28.99 % for buffaloes fed T2 and T3, respectively compared to control ration (T1). Difference among buffaloes fed T2 and those fed T3 were significant ( $P < 0.05$ ). The superiority was 9.55 % in favor buffaloes fed T3. As shown in

Table (4), the differences in plasma cholesterol values were significantly ( $P<0.05$ ) affected by the experimental fat supplementation. The buffaloes fed supplemented fat ration had higher ( $P<0.05$ ) values for plasma cholesterol. The increment was 17.16 and 40.30 % for T2 and T3, respectively compared to the control ration. The concentrations of triglycerides were higher ( $P<0.05$ ) for buffaloes fed T2 and T3 than those fed the control ration. These increases were 42.57 and 101.12 % when treatments T2 and T3 were compared with T1. At the same time, there was a significant ( $P<0.05$ ) increase in triglycerides values for buffaloes fed T3 compared with those fed T2. The increment represents 24.31 % for T3 above T2.

#### **Plasma hormones:**

Results indicated that T3 treatment increased ( $P<0.05$ ) plasma triiodothyronine level by 20.66 and 14.06% more than T1 and T2 respectively, (Table 4). The results revealed that, addition of fat to lactating buffaloes as 10% (T2) and 15 % (T3) of their metabolizable energy requirements increased their plasma thyroxin level. This increase was 26.63 and 47.84% for T2 and T3, respectively in comparison with T1. Also, thyroxin level was greater ( $P<0.05$ ) by 16.75 % upon feeding treatment T3 compared with T2. Data in Table (4) also showed that the calculated thyroxin/triiodothyronine ratio increased ( $P<0.05$ ) by 19.68 and 22.53 % for buffaloes fed T2 and T3 rations when compared with the control ration. Buffaloes fed T3 showed higher ratio (2.38 %) than those fed T2, but the variance did not achieve a significant effect.

#### **DISCUSSION**

The improvement in milk yield by 18.9 and 35.8 % for buffaloes fed T2 and T3 compared to control ration is in agreement with the results of Purushothaman *et al.* (2008). They indicated that supplementing the ration of lactating cows with calcium salts of palm oil fatty acids caused a substantial improvement in the milk yield. They reported that 4 % bypass fat supplementation showed a significant increase in milk yield by 19.0 % as compared to the control. In the present study, the increases in 7% FCM were calculated to be 25.78 and 52.75% and the milk fat yield also increased by 28.1 and 58.6% for buffaloes fed calcium salts of palm oil fatty acids supplemented rations. These results are in agreement with Petit *et al.* (2004) who stated that milk yield, FCM and milk fat yield increased by 27.0, 25.1 and 23.5%, respectively for lactating cows fed 4.6% calcium salts of palm oil compared with the control diet. It is interesting to notice that the

TDMI increment as a result of fat supplementation. These results are in agreement with the study of Chan *et al.* (1997) and Basiony (1998). They reported that DMI increased by 13.6 and 16.35 % for cows and buffalo calves fed 2.5% prilled fatty acids, respectively compared with those fed the control ration. Thus, the efficiency of FCM per kg TDMI was also improved for lactating buffaloes fed calcium salts of palm oil fatty acids in the present study.

The significant reduction observed in RT at 8.00 am and 2.00 pm for buffaloes fed protected fat supplemented rations could be understood as significantly lower heat production. In other words, it reduced significantly less heat increment and heat of fermentation. This means more efficient utilization of dietary digestible and metabolizable energy. In the same way, greater portion of dietary energy is used for productive aspects. Accordingly the milk yield, 7% FCM and milk fat yield were enhanced in the present study. As reported by Zhang *et al.* (2011), 1.5% dietary fat supplementation in early-lactating cows decreased RT and RR, discussing that fat has a low heat increment associated with feeding, and is also accompanied by a high energy density, thus it is utilized with high efficiency. Although fat supplementation of calcium salts of fatty acids (1.5% of diet) in high-yielding dairy cows was effective in reducing metabolic heat production, increasing the energy density, and thus increased metabolic efficiency to enhance milk production, however, the changes were not reflected in RT and RR (Moallem *et al.*, 2010). Rectal temperatures at 1400 h decreased accompanied with fat supplementation, demonstrating a remarkable amount of metabolic heat that is saved by energetically replacing fermentable carbohydrates with supplemental fat (Wang *et al.*, 2010).

It is quiet accepted that the RT is affected by the environmental temperature. The temperature of the stable was 14.21 °C at 8 am, while it was 24.5 °C at 2.00 pm. Therefore, it is reasonably to find higher RT at 2.00 pm than at 8 am. Discussing the RR data could not be done away from the RT results, where both of them are expression for the balance between the internal biological system and the animal surrounding environment. The respiration rate data express that animals fed protected fat supplemented rations are in more comfortable and relaxant state. Respiration is one of the ways that enable animals to get rid of the excessive heat. This fact was strictly clear when RR values recorded at 2.00 pm were higher in comparison with the RR values at 8.00 am of this study.

Blood Hb is responsible for cellular oxidation through O<sub>2</sub> supply and washing out the un-required CO<sub>2</sub>. High Hb concentration in blood of protected fat fed buffaloes indicates greater supply of O<sub>2</sub> that required for metabolic and synthetic processes, leading to greater milk and milk constituents yields (Vandeharr, 2005). Such increase in blood Hb was accompanied with significant higher values of MCH values. As a matter of fact, variation in Hb synthesis is reflected by increasing or decreasing in MCH values (Benjamin, 1978). The present results of PCV% increased significantly in animals fed protected fat supplemented ration. These results are in agreement with those of Soliman *et al.* (2001) who reported that PCV% increased for dairy cows fed fat-supplemented diets compared with control diet. The increment in WBC's in animals fed fat supplemented ration may express the better hygienic situations as high producing animals are more susceptible to microbial invasion than lower producing animals.

Fat supplementation may help in saving glucose from oxidation to be used in lactose synthesis (Vandeharr, 2005). Feeding Holstein cows rumen-protected fat (50 g/kg DM), showed greater milk and lactose yields associated with elevation in lipids and glucagon concentrations despite lower plasma glucose concentration, suggesting a glucose-sparing effect allowing an enhanced lactose synthesis (Hammon *et al.*, 2008). Other possible reasons were that supplemental fat would provide precursors for gluconeogenesis, thereby increasing blood glucose concentration, or that glycolysis of sugar was inhibited by supplemental dietary fat in order to improve their energy levels (Juchema *et al.*, 2008). It should consider that bypass fats are hydrolyzed to their polyunsaturated fatty acids and glycerol, a precursor for glucose (Morsy, 2008). The response of increasing plasma glucose shown in the present study is in accordance with studies of Garcia *et al.* (1998), Petit *et al.* (2004), Harvatine and Allen (2005), Juchema *et al.* (2008) and Zhang *et al.* (2011). Petit *et al.* (2004) found a significant increase amounted in plasma glucose by 5.09% for cows fed 4.6% calcium salts of palm oil. In addition, cows fed calcium salts of fish and palm oil had greater concentrations of glucose which can be related to plasma insulin concentrations (Juchema *et al.*, 2008), as plasma insulin concentration was decreased by 27% for cows fed calcium salts of unsaturated fatty acids (Harvatine and Allen, 2005). Another work on dairy cows showed no change in their plasma glucose due to fat supplementation (Christensen *et al.*, 1996). In

contrast, plasma glucose was slightly decreased for dairy cows fed diets containing 3% Ca salts of long chain fatty acids (Erickson *et al.*, 1992).

A tendency to increase plasma total protein in the present study was also observed in dairy cows fed fat-supplemented rations (Soliman *et al.*, 2001). Such trend was in accordance with milk protein content and ascertains the merit for improving milk production performance of animals according to increasing the dietary energy density (Fahmy *et al.*, 2000). It should consider that plasma albumin is an important source of available amino acids that can support amino acids need when dietary supplies are limited (Moorby *et al.*, 2002). Blood amino acids are used in several aspects such as in gluconeogenesis, synthesis of milk protein, synthesis of enzymes secreted via gastric juice and restoring cell deprive. Therefore, its concentration in blood are the balance among these issues (Vandeharr, 2005).

Buffaloes fed protected fat supplemented rations showed higher plasma concentrations of total lipids, cholesterol and triglycerides. Similar response was observed in dairy cows due to dietary fat supplementation (Soliman *et al.*, 2001). Fat supplementation, in addition to its effect to improve milk production, increased the ether extract (%) and its digestibility coefficients as a result to feeding Ca salts of palm oil fatty acids in lactating cows (Purushothaman *et al.*, 2008). Accordingly, the elevated plasma total lipids concentration was accompanied with a significant increase in milk fat yield as pointed out in the present study. This increment in total lipid concentration exerted its effect on fat concentration of milk and the yield of milk fat in dairy cows (Fahmy *et al.*, 2000). The present results are consistent with a study concluded that supplementation of Friesian bull's diet with 4 or 8 % Ca soap of fatty acids increased plasma total lipids by 14 and 17 % compared with those fed the control diet (Omer, 1999). Likewise, Petit *et al.* (2004) observed that cholesterol concentrations were significantly higher for cows fed 4.6% calcium salts of palm oil compared with those fed the control diet. Plasma non-esterified fatty acid and triglyceride concentrations were significantly increased in Holstein cows fed rumen-protected fat (50 g/kg DM), revealing an elevation in their lipid status (Hammon *et al.*, 2008). As reported by Zhang *et al.* (2011), dietary fat supplementation induced significant increases in total triglycerides, total cholesterol and high density lipoprotein in early-lactating cows. However, addition of Ca salts of fatty acids at levels of 3 or 5 % to the diets of lactating dairy goats in early lactation have

limited effect on blood levels of cholesterol and triglycerides (Titi, 2011). Blood levels of total lipids, cholesterol and triglyceride reflected the *in vivo* metabolism of lipids, and strong lipid metabolism can release more energy to decrease the duration and magnitude of negative energy status. In the same way, Christensen *et al.* (1996) documented that utilization of fat in dairy cows diet is positively reflected in their plasma cholesterol, attributing such rises in plasma cholesterol to the greater demand for cholesterol in processes of lipid digestion, absorption, transport and synthesis in the mammary gland. In addition, the increase of cholesterol level is required for absorption and transport of long chain fatty acids. Contrary to above, plasma cholesterol level was not changed by dietary fat supplementation as 5 % Ca soap of fatty acids (Sklan *et al.*, 1994).

It is quiet known that thyroid gland through its hormonal secretions (thyroproteins) master the general body metabolism and energy metabolism in particular (Frandsen, 1986). The relation between protected fat supplementation and thyroid hormone concentrations could be due to more absorbed nutrients available to be metabolized. Substrate accumulation may accelerate the metabolic rate that is controlled by thyroid hormones. Moreover, it is known that animals eat to cover their needs from energy and protein (Forbes, 2000). According to the animals genetic potential the high producing animals ate more, the digestibility and metabolizability processes working more efficient and faster as a result of greater concentration of thyroid hormones. That was the case in this study where triiodothyronine concentrations were increased. The increase in thyroxin concentrations due to fat supplementation is in agreement with Grum *et al.* (1996) and Soliman *et al.* (2001) who worked on dairy cows fed fat-supplemented diets.

The present study concluded that protected fat supplementation in Egyptian lactating buffaloes can be improved their physiological responses and milk production, indicating that the efficient metabolic activities of these animals were enhanced.

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**Table 1. Effect of protected fat supplementation on some productive performances of lactating Egyptian buffaloes (mean±S.E.)**

Items	Treatments			Mean S.E.	Sig.
	T1	T2	T3		
Milk yield (kg/h/d)	8.25 <sup>c</sup>	9.81 <sup>b</sup>	11.20 <sup>a</sup>	0.242	*
7 % FCM (kg/h/d)	8.38 <sup>c</sup>	10.54 <sup>b</sup>	12.80 <sup>a</sup>	0.278	*
Fat yield (kg/d)	0.590 <sup>c</sup>	0.756 <sup>b</sup>	0.936 <sup>a</sup>	0.001	*
TDMI (kg/h/d)	16.67 <sup>c</sup>	17.97 <sup>b</sup>	19.64 <sup>a</sup>	1.273	*
FCM/TDMI	0.50 <sup>c</sup>	0.59 <sup>b</sup>	0.65 <sup>a</sup>	0.005	*

<sup>a and b</sup> Means in the same row having different superscripts are significantly (P<0.05) different.

7% FCM = 0.265 milk yield+10.5 fat yield (Raffat and Saleh, 1962).

TDMI= Total dry matter intake.

T1= 100% of the metabolizable energy requirements (Control)

T2= 110% of the metabolizable energy requirements by adding protected fat.

T3= 115% of the metabolizable energy requirements by adding protected fat.

**Table 2. Effect of protected fat supplementation on rectal temperature and respiration rate of lactating Egyptian buffaloes (mean±S.E.)**

Items	Treatments			Mean S.E.	Sig.
	T1	T2	T3		
Rectal temperature, °C					
8 am	37.88 <sup>a</sup>	37.49 <sup>b</sup>	37.34 <sup>b</sup>	0.007	*
2 pm	38.29 <sup>a</sup>	37.86 <sup>b</sup>	37.65 <sup>b</sup>	0.015	*
Respiration rate, rpm					
8 am	25.25	23.75	23.50	2.50	NS
2 pm	36.38 <sup>a</sup>	30.88 <sup>b</sup>	29.50 <sup>b</sup>	3.26	*

<sup>a and b</sup> Means in the same row having different superscripts are significantly (P<0.05) different.

NS = Not significant.

T1= 100% of the metabolizable energy requirements (Control)

T2= 110% of the metabolizable energy requirements by adding protected fat.

T3= 115% of the metabolizable energy requirements by adding protected fat.

**Table 3. Effect of protected fat supplementation on blood hematological parameters of lactating Egyptian buffaloes (mean±S.E.)**

Items	Treatments			Mean S.E.	Sig.
	T1	T2	T3		
Hb (g/dl)	13.0 <sup>b</sup>	14.69 <sup>a</sup>	15.93 <sup>a</sup>	0.351	*
PCV (%)	31.5 <sup>b</sup>	35.5 <sup>a</sup>	38.0 <sup>a</sup>	1.944	*
RBC's (x 10 <sup>6</sup> /mm <sup>3</sup> )	6.93 <sup>b</sup>	7.30 <sup>ab</sup>	7.62 <sup>a</sup>	0.052	*
WBC's (x 10 <sup>3</sup> /mm <sup>3</sup> )	8.39 <sup>b</sup>	8.67 <sup>ab</sup>	8.91 <sup>a</sup>	0.017	*
MCH (µg)	18.78 <sup>b</sup>	20.14 <sup>a</sup>	20.41 <sup>a</sup>	0.436	*
MCV (Cu. µ)	45.49 <sup>b</sup>	48.52 <sup>ab</sup>	49.90 <sup>a</sup>	2.929	*
MCHC (%)	41.29	41.50	41.92	0.858	NS

<sup>a and b</sup> Means in the same row having different superscripts are significantly (P<0.05) different.

NS = Not significant.

T1= 100% of the metabolizable energy requirements (Control).

T2= 110% of the metabolizable energy requirements by adding protected fat.

T3= 115% of the metabolizable energy requirements by adding protected fat.

The values of MCH, MCV and MCHC were calculated according to Schalm (1965).

**Table 4. Effect of protected fat supplementation on plasma metabolites, thyroid hormones and prolactin of lactating Egyptian buffaloes (mean±S.E.)**

Plasma constituents	Treatments			Mean S.E.	Sig.
	T1	T2	T3		
Glucose (mg/dl)	59.5 <sup>c</sup>	69.0 <sup>b</sup>	75.0 <sup>a</sup>	0.500	*
Total protein (g/dl)	7.08 <sup>b</sup>	7.43 <sup>a</sup>	7.72 <sup>a</sup>	0.019	*
Albumin (g/dl)	3.80 <sup>b</sup>	4.10 <sup>a</sup>	4.13 <sup>a</sup>	0.011	*
Globulin (g/dl)	3.28 <sup>b</sup>	3.33 <sup>b</sup>	3.59 <sup>a</sup>	0.004	*
A/G ratio	1.16	1.23	1.15	0.001	NS
Total lipid (mg/dl)	422.5 <sup>c</sup>	497.5 <sup>b</sup>	545.0 <sup>a</sup>	0.481	*
Cholesterol (mg/dl)	67.0 <sup>c</sup>	78.5 <sup>b</sup>	94.0 <sup>a</sup>	0.543	*
Triglycerides (mg/dl)	25.25 <sup>c</sup>	36.00 <sup>b</sup>	44.75 <sup>a</sup>	1.167	*
Triiodothyronine (ng/ml)	1.21 <sup>b</sup>	1.28 <sup>b</sup>	1.46 <sup>a</sup>	0.002	*
Thyroxin (ng/ml)	41.68 <sup>c</sup>	52.78 <sup>b</sup>	61.62 <sup>a</sup>	0.023	*
Thyroxin/triiodothyronine ratio	34.45 <sup>b</sup>	41.23 <sup>a</sup>	42.21 <sup>a</sup>	1.460	*

A, b and c Means in the same row having different superscripts are significantly (P< 0.05) different.

NS = Not significant.

T1= 100% of the metabolizable energy requirements (Control).

T2= 110% of the metabolizable energy requirements by adding protected fat.

T3= 115% of the metabolizable energy requirements by adding protected fat.

### بعض الإستجابات الإنتاجية والفسلوجية للجاموس المصرى الحلاب نتيجة التغذية على علائق مزودة بالدهن المحمي

عبد المعطى خيرى ابراهيم ، عصام بسيونى سليمان ، سمير توفيق محمد ، عماد الدين محمد ابراهيم

قسم الإنتاج الحيوانى، كلية الزراعة، جامعة المنيا

أجريت هذه الدراسة على عدد 6 من الجاموس المصرى الحلاب فى موسم الحليب الثانى وموسم الحليب الرابع بعد وصولها الى قمة منحنى اللبن وذلك بهدف تقييم بعض الإستجابات الإنتاجية والفسلوجية لهذه الحيوانات عند تغذيتها على 3 معاملات. المعاملة الأولى أستخدمت كمنترول وتم تغذيتها على علفية تغطى 100% من الإحتياجات الغذائية كطاقة ممثلة، بينما تم تكوين المعاملات الثانية والثالثة بإضافة الدهن المحمي (أملاح الكالسيوم للأحماض الدهنية لزيت النخيل) لتوفير 110، 115 % من الطاقة الممتلئة على التوالي، وقد تساوت المعاملات الثلاثة فى محتواها من البروتين الممتلئ (91.44 جم بروتين ممتلئ/كجم مادة جافة) كما تم تقديم مصاصة القصب كمادة مألوفة لحيوانات التجربة لحد الشبع.

أظهرت النتائج أن إضافة الدهن المحمي الى علائق الجاموس الحلاب أدى الى زيادة معنوية فى كل من محصول اللبن ، ناتج اللبن المعدل لنسبة دهن 7 % ، محصول دهن اللبن والمادة الجافة الكلية المأكولة وذلك للحيوانات التى تغذت على المعاملتين الثانية والثالثة على التوالي مقارنة بتلك التى تغذت على المعاملة الكنترول. لوحظ إنخفاض معنوى فى درجة حرارة المستقيم المسجلة عند الثامنة صباحاً وعند الثانية بعد الظهر وكذلك قيم معدل التنفس المسجلة عند الثانية بعد الظهر وذلك للحيوانات التى تغذت على المعاملتين الثانية والثالثة على التوالي مقارنة بتلك التى تغذت على المعاملة الكنترول. لوحظت زيادة معنوية فى القيم الهيماتولوجية للدم (تركيز الهيموجلوبين، حجم المكونات الخلوية، عدد كرات الدم الحمراء، عدد كرات الدم البيضاء، متوسط تركيز الخلايا، متوسط حجم الخلايا) وكذلك محتوى البلازما من الجلوكوز، البروتينات الكلية، الألبومين، الجلوبيولين، الليبيدات الكلية، الكولستيرول، الجليسريدات الثلاثية وذلك للحيوانات التى تغذت على المعاملتين الثانية والثالثة على التوالي مقارنة بتلك التى تغذت على المعاملة الكنترول. وأظهرت النتائج أيضاً زيادة معنوية فى محتوى البلازما من هرمونات الدرقية (تراي ايودوثيرونين والثيروكسين) وذلك للحيوانات التى تغذت على المعاملتين الثانية والثالثة على التوالي مقارنة بتلك التى تغذت على المعاملة الكنترول.

نستنتج من هذه الدراسة أن إضافة الدهن المحمي الى علائق الجاموس الحلاب أدى الى تحسين بعض الإستجابات الإنتاجية والفسلوجية لهذه الحيوانات وهذا يرجع الى رفع كفاءة الأنشطة الحيوية لها.