

Response of Male Lambs to Concentrate Mixtures given with or without Natural Clay under Egypt Conditions

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Abstract: Lambs given diets containing concentrate mixture without roughages were better in daily weight gain, economical and feed efficiencies, carcass weight, dressing percentage and lying time than those fed on diets containing roughages. However, contrary trends were found in case of filled gut, eating time, rumination time, frequencies of drinking water, micturition, defecation, mounting and licking block minerals, rectal temperature and respiration rate, with the same treatment. Lambs given diets containing natural clay surpassed those not given natural clay in final weight, daily gain weight, economical efficiency, feed efficiency, water intake, eating time, rumination time, lying time and frequencies of drinking water and mounting. While, contrary trends were shown in defecation frequency, licking block minerals frequency, rectal temperature and respiration rate. The full concentrate mixture diet (without roughages) plus natural clay surpassed the other diets in final weight, daily weight gain, economical and feed efficiencies, dressing percentage and lying time. On the other hand, lower values were recorded in case of empty gut weight, eating time, rumination time, frequencies of drinking water, defecation, mounting and licking block minerals, rectal temperature and respiration rate, with the same treatment. T3 was significantly lower in lambs fed concentrate mixture alone than in the other diets. At the same time, T4 was significantly higher in lambs fed the diets containing concentrate + roughages than in those fed the other diets.

Key words: Fattening male lambs, concentrate mixture diet, natural clay supplementation, behavior, hot climate

In hot climate, farm animals experience many stresses, of which, heat stress is the most important. Since it evokes a series of changes in their biological functions that cause impairment in appetite, feed intake, feed efficiency and feed utilization, disturbances in water, protein, energy and mineral balances, leading to impairment of their productive and reproductive efficiencies (Rodriguez *et al.*, 1985; Silva *et al.*, 1991; Habeeb *et al.*, 1992; 1997; Wildman and Hammond, 1993 and Marai *et al.*, 1995,

1997a,b,c and 1998). Digestion of highly lignified fibrous feeds increases the heat output and heat load when animals are already under heat stress. On the other hand, the literature shows that better productive and reproductive traits may be realized by feeding full concentrate mixture (El-Serafy, 1990) or by dietary supplementation with natural clay (Ayyat and Marai, 1997). Feeding lambs on full concentrate ration was found to be more efficient than the normal (roughages + concentrate) feed (Folman and Eyal, 1978;

EL-Serafy, 1990; Murphy *et al.*, 1994 and Shehata and El-Sayed, 1994).

Feed supplementation with few natural clays was found to improve digestibility of dry matter and protein (Kirilov and Bunkhonov, 1993), organic matter, nitrogen free extract (Chesmedzhiev *et al.*, 1981), by increasing the reactive surface areas of nutrients, thus promoting the action of digestive enzymes and the area of contact with the mucous membrane of the digestive tract (Pulatov *et al.*, 1983). In addition, it increased the absorption of Ca and P, and availability of Mn, Cu, Zn and Fe (El-Gendy *et al.*, 1993 and El-Hakim *et al.*, 1993), and retention of trace minerals in the animal bodies (Kalyuzhnov *et al.*, 1988). The ability of natural clays to adsorb up to 15% ammonia from rumen solution, when its concentration is high and its gradual release during the after-feeding fermentation period (White and Ohlrogge, 1974), allows rumen micro-organisms to synthesize cellular protein continuously for easy assimilation into the animal digestive system (Mumpton and Fishman, 1977). Natural clays may also stimulate the lining of the stomach and intestinal tract, that increases the production of antibodies that inhibit the onset of enteritis (Mumpton and Fishman, 1977) and decrease diarrhoea and other disorders (Watanabe *et al.*, 1971). Liquid fractional rate of passage and liquid flow rate and fraction/rate of passage of food particles in digestive tract were found to decrease with the inclusion of natural clay in diets (White and Ohlrogge, 1974).

The present study was planned to test the ability of the heat-stressed male fattening lambs to withstand heat stress effects by feeding on a concentrate mixture alone (feeds

with low fiber-high nutritional content) supplemented with natural clay that may improve their feed conversion. The traits studied included growth performance, economical efficiency, carcass traits, some behavioral traits and physiological reactions.

Materials and Methods

The present study was carried out at Zagazig University, Zagazig, Egypt. The experimental work was conducted in the Experimental Station, El Gemmaiza, (30.5°N), belonging to Institute of Animal Production Research, Ministry of Agriculture, Egypt.

In the present study, conducted during April-July (beginning of the hot period of the year), 40 healthy Suffolk crossbred (Suffolk x Ossimi) male weaned docked lambs, 60-70 days of age with nearly equal body weights, were used. The animals were divided in four groups (A, B, C and D). Animals of Group A (Control) were offered fattening nutritional requirements according to Ghoneim (1967) and NRC (1985), containing concentrate mixture + roughages (TDN = 56.2, SV = 35.0 and DCP = 8.5). Group B was fed as Group A + 6 kg natural clay per 100 kg ration (TDN = 59.9, SV = 39.3 and DCP = 8.5). Group C was fed *ad libitum* concentrate mixture only (without roughages; TDN = 55.5, SV = 34.3 and DCP = 11.9). Group D was fed as Group C + 6 kg natural clay per 100 kg ration (TDN = 59.3, SV = 38.4 and DCP = 11.9). The natural clay was brought from Belbies, Sharkia Governorate, Egypt, then crushed and ground until became dust and added to the diets. The natural clay contained soluble anions (mg g⁻¹ soil): CO₃⁻ 0.00, HCO₃⁻ 5.6, Cl⁻ 11.5 and SO₄⁻ 24.4, and as soluble

Table 1. Growth performance traits, feed efficiency and water consumption (Mean±S.E.) of male fattened lambs

Treatments	Initial weight (kg)	Final weight (kg)	Daily weight gain (g)	Economical efficiency relative to control (%)	Feed efficiency (kg gain/kg DM)	Water intake (L/head/day)
Natural clay (N)						
Diet without clay	24.1±1.3	42.7 ^b ±1.3	217.1±9.3 ^b	100.0	0.2	4.4
Diets with clay	23.9±1.0	47.9 ^a ±1.3	245.7±1.3	126.0	0.3	4.9
Significance	NS	*	**			
Concentrate mixture (C)						
Diets with roughages	24.0±1.0	44.0 ^a ±1.3	202.7 ^b ±9.3	100.0	0.2	5.2
Diets without roughages	23.9±1.0	46.1±1.3	260.4 ^a ±9.1	128.9	0.3	4.0
Significance	NS	NS	**			
Interactions (NxC)						
C mixture + roughages (Control)	24.1±1.5	41.4 ^b ±2.0	188.4 ^c ±13.5	100.0	0.2	4.8
C mixture + roughages + clay	24.0±1.4	43.9 ^{ab} ±1.9	216.3 ^{bc} ±12.8	126.6	0.2	5.7
C mixture only	23.9±1.4	46.5 ^{ab} ±1.9	245.8 ^{ab} ±12.8	129.5	0.2	4.0
C mixture + clay	23.9±1.4	49.2 ^a ±1.9	275.0 ^a ±12.8	162.8	0.3	4.1
Significance	NS	*	*			

Mean bearing different letter within the same classification differ significantly (P<0.05).

** P<0.01; * P<0.05; NS = Not significant; Economic efficiency = Economical efficiency relative to control (%).

cations (mg g⁻¹ soil): Ca⁺⁺ 3.4, Mg⁺⁺ 2.0, Na⁻ 36.0, and K⁺ 0.1, Pb 0.43 ppm, Cu 0.0 ppm, Zn 0.0 ppm and Fe 0.2 ppm. Feeding values as TDN, SV and DCP were calculated according to Bredon *et al.* (1963 a,b) using the following equations:

$$\text{TDN} = 129.39 - 0.9419 (\text{CF} + \text{NFE})$$

$$\text{SV} = 120.80 - 1.104 (\text{CF} + \text{NFE})$$

$$\text{DCP} = 0.9596 \text{ CP} - 3.55$$

Before beginning of the experiment, feed was gradually increased through 8 days period until it reached required level. Daily consumption of feed was recorded. Water was offered freely to all animals and water consumption was estimated daily.

Lambs were housed in semi-open sheds during the experimental period. The shed was divided in four pens, each of 9 x 4 m, soil floored and partially (4 x 4 m) roofed with asbestos. The pen was surrounded by 12 cm brick walls. The height of the north wall was 4 m with 0.5 x 3 m open window. The height of the other walls including the south walls and the partitions between the pens was 2 m.

Ambient air temperature (dry bulb temperature) and relative humidity (RH%) inside the shed were recorded while testing the physiological traits. Ambient tempera-

tures (minimum 18.9 and maximum 35.4°C) were recorded using thermometer to the nearest 0.1°C. RH was recorded using hair-hygrometer to the nearest 1%. The temperature-humidity index (THI) was estimated by formula of LPHSI (1990) following modified:

$$\text{THI} = \text{db}^\circ\text{C} - [(0.31 - 0.31 \text{ RH}) (\text{db}^\circ\text{C} - 14.4)],$$

where,

db°C is dry bulb temperature in °Celsius and RH is RH % /100. The values of THI obtained were classified as follows: 22.2 = absence of heat stress, 22.2 to <23.3 = moderate heat stress, 23.3 to <25.6 = severe heat stress and 25.6 and more = very severe heat stress (the same formula can be used to estimate THI for big animals, i.e., cattle, buffaloes and goats).

Animals were weighed on two successive days at the beginning of the experiment, then at 15 day interval until the animals reached 45 kg live body weight. Rectal temperature and respiration rate were measured three times at 8.00, 12.00 and 16.00 h at weekly interval, during the experimental period.

Blood samples (5 ml) were collected from the jugular vein at 12.00 h at 15 day interval into 10 ml evacuated glass tubes containing heparin as anticoagulant and centrifuged at 2000 rpm for 15 minutes. Plasma was collected and stored at -10°C until analyzed. Total thyroxin (T4) and triiodothyronine (T3) uptake percentages were estimated using solid phase coated tubes labelled with ¹²⁵I (Diagnostic Products Corporation, Los Angeles, USA) by radioimmunoassay technique.

Table 2. Carcass traits (Mean±S.E.) of male fattened lamb

Parameter (Treatments)	Carcass weight (kg)	Dressing percentage	Prime cuts (%)	Filled gut (kg)	Empty gut (kg)
Natural clay (N):					
Diet without clay	22.7±0.6	53.0±0.9	79.6±0.7	19.5±0.7	8.1±0.9
Diets containing clay	23.1±0.6	54.0±0.9	79.6±0.7	19.4±1.2	7.8±0.8
Significance	NS	NS	NS	NS	NS
Concentrate mixture (C):					
Diets with roughages	21.6 ^a ±0.6	51.1 ^b ±0.9	79.4±0.7	21.4 ^a ±9.1	9.4±0.9
Diets without roughages	24.1 ^a ±0.6	56.0 ^a ±0.9	79.9±0.7	17.5 ^b ±9.1	6.5±0.9
Significance	*	*	NS	*	NS
Interactions (NxC):					
C + roughages (Control)	21.2±0.9	50.0 ^b ±1.2	79.5±1.0	22.7 ^a ±1.7	9.8 ^a ±1.2
C mixture + roughages + clay	24.0±1.4	43.9 ^{ab} ±1.9	79.5±1.0	20.1 ^{ab} ±1.7	8.8 ^a ±1.2
C mixture only	23.9±1.4	46.5 ^{ab} ±1.9	79.9±1.0	16.2 ^b ±1.7	6.4 ^b ±1.2
C mixture + clay	23.9±1.4	49.2 ^a ±1.9	79.8±1.0	18.7 ^{ab} ±9.1	6.5 ^b ±1.2
Significant	NS	*	NS		

Mean bearing different letter within the same classification.

*P<0.05; NS = Not significant.

Table 3. Weight of lean meat, bone and fat in the carcass of male fattened lambs as affected by type of feeding

Parameter (Treatments)	Lean weight in carcass (kg)	Fat weight in carcass (kg)	Bone weight in carcass (kg)
Natural clay effect (N)			
Diet without clay	12.4±0.8	6.1±0.6	4.2±0.2
Diets with clay	13.7±0.8	5.5±0.6	3.9±0.2
Significance	NS	NS	NS
Concentrate mixture (C)			
Diets with roughages	12.3±0.8	5.6±0.6	3.7±0.2
Diets without roughages	13.8±0.8	5.9±0.6	4.4±0.2
Significance	NS	NS	NS
Interactions (Nx C)			
C + roughages (Control)	11.4±1.1	6.0±0.9	3.9±0.3
C + roughages + clay	13.2±1.1	5.3±0.9	3.6±0.3
C only	13.3±1.1	6.1±0.9	4.6±0.3
C + clay	14.2±1.1	5.7±0.9	4.2±0.3
Significance	NS	NS	NS

NS = Not significant.

During the experimental period, three numbered animals were selected randomly from each group for behavioral studies. The behavioral data were collected at weekly interval by visual observations thrice between 7.00-11.00, 11.00-15.00 and 15.00-19.00 h on time spent in feeding, ruminating and lying and frequency of drinking water, micturition, defecation, sexual activity (mounting) and licking block minerals.

When the animal groups reached the average marketing weight (45 kg), three representative lambs from each group were fasted for 16 h and slaughtered for studying carcass traits. After slaughter, the carcasses were chilled and dissected into wholesale cuts (legs, loin, rack, flank, neck and shoulders). Legs, loin, rack and shoulders were considered as prime cuts. The 9th to 11th rib cuts were chilled, and separated to lean, bone and fat for studying the physical

composition of the carcass. The following weights were recorded: live body at slaughter, hot carcass and digestive tract (full and empty). Dressing percentage value was calculated as weights of hot carcass + liver, heart and kidneys, relative to fastened body weight. Percentage of prime cuts (legs, loin, rack and shoulder) weight, relatively to the same body weight, was also estimated.

The weights of either lean meat, fat or bone in the carcass were estimated according to Field *et al.* (1963) and Mokhtar (1974) and modified as follows:

Lean (L), or fat or bone weight in the carcass = [L (or fat or bone) weight in 9-10-11th rib cut/9-10-11th rib cut weight] x hot carcass weight.

Proximate analyses of the concentrate mixture and roughages were carried out as

Table 4. Least squares means (\pm S.E.) of some behavioral traits of male fattened lambs as affected by inclusion of natural clay or concentrate mixtures in their diets, during April-July months (35.4-18.9°C).

Treatments	Eating time (Minute/time of day)	Rumination time (Minute/time of day)	Lying time (Minute/time of day)	Drinking (Frequency/time of day)	Micturition (Frequency/time of day)	Defecation (Frequency/time of day)	Mounting (Frequency/time of day)	Licking block minerals (Frequency/time of day)
Natural clay effect (N):								
Diet without clay	44.1 ^b \pm 1.0	20.9 ^b \pm 0.9	89.4 ^b \pm 1.6	2.3 ^b \pm 0.1	2.6 \pm 0.1	2.5 ^d \pm 0.1	0.6 ^b \pm 0.1	1.1 ^a \pm 0.1
Diets containing clay	45.9 ^a \pm 1.0	28.2 ^a \pm 0.9	106.1 ^a \pm 1.6	3.1 ^a \pm 0.1	2.8 \pm 0.1	1.6 ^b \pm 0.1	0.8 ^a \pm 0.1	0.1 ^b \pm 0.1
Significance	**	**	**	**	NS	**	**	**
Concentrate mixture (C):								
Diets with roughages	54.4 ^a \pm 1.0	35.2 ^a \pm 0.9	74.8 ^b \pm 1.6	2.8 ^a \pm 0.1	3.3 ^a \pm 0.1	2.4 ^a \pm 0.1	1.2 ^a \pm 0.1	0.7 ^a \pm 0.1
Diets without roughages	36.2 ^b \pm 1.0	13.9 ^b \pm 0.9	120.7 ^a \pm 1.6	2.5 ^b \pm 0.1	2.1 ^b \pm 0.1	1.7 ^b \pm 0.1	0.2 ^b \pm 0.1	0.4 ^b \pm 0.1
Significance	**	**	**	**	**	**	**	**
Interactions (Nx C):								
C + roughages (Control)	53.4 ^a \pm 2.9	28.9 ^b \pm 1.8	66.0 ^d \pm 3.7	2.4 ^a \pm 0.1	3.2 ^a \pm 0.1	2.8 ^a \pm 0.1	1.2 ^a \pm 0.1	1.3 ^a \pm 0.1
C + roughages + clay	55.4 ^a \pm 2.9	41.5 ^a \pm 1.8	83.6 ^c \pm 3.7	3.2 ^a \pm 0.1	3.4 ^a \pm 0.1	1.9 ^b \pm 0.1	1.3 ^a \pm 0.1	0.2 ^c \pm 0.1
C only	35.9 ^b \pm 2.9	13.0 ^c \pm 1.8	112.9 ^b \pm 3.7	2.1 ^b \pm 0.1	2.0 ^b \pm 0.1	2.1 ^b \pm 0.1	0.04 ^b \pm 0.1	0.9 ^b \pm 0.1
C + clay	36.5 ^b \pm 2.9	14.9 ^c \pm 1.8	128.5 ^b \pm 3.7	3.0 ^b \pm 0.1	2.2 ^a \pm 0.1	1.3 ^c \pm 0.1	0.3 ^b \pm 0.1	0.01 ^c \pm 0.1
Significant	NS	**	*	**	**	**	*	**

Means bearing different letters within the same classification, differ significantly ($P < 0.01$); ** = $P < 0.05$; NS = Not significant.

per AOAC (1980). Natural clay was chemically analyzed in the Central Laboratory, Faculty of Agriculture, Zagazig University, Zagazig, Egypt. Assays of T3 and T4 were performed at the Laboratory of Sheep and Goats Division, Institute of Animal Production Research, Ministry of Agriculture, Giza, Egypt.

The economical efficiency was calculated as the net income relative to that of the control.

Prior to the statistical analysis, percentage values were transformed into Arcsine. Data concerning growth performance, slaughter traits, T3 and T4 were statistically analyzed in a 2x2 factorial design using the following Model (Model 1):

$$Y_{ij} = h + t_i + f_j + t_{ifj} + e_{ij}$$

where,

h = overall mean, t_i = fixed effect of i^{th} diet containing natural clay ($i = 1, 2$), f_j = fixed effect of j^{th} diet including roughages ($j = 1, 2$), t_{ifj} = interaction between natural clay addition and inclusion of roughages in the diet and e_{ij} = random error. Data obtained on behavioral and physiological reactions were statistically analyzed in a 2 x 2 x 3 factorial design using the following Model (Model 2):

$$Y_{ijk} = h + t_i + f_j + p_k + t_{ifj} + t_{ipk} + f_{jpk} + t_{ifjpk} + e_{ijk}$$

where,

t_i , f_j and t_{ifj} are same as in Model 1, p_k = fixed effect of time of day ($k = 1, 2$ and 3), t_{ipk} = interaction between effect of natural clay and time of day, f_{jpk} = interaction between inclusion of roughages and time of day and t_{ifjpk} = interaction between inclusion of natural clay and

roughages in diets and time of day (not included in the results and discussion) and e_{ijk} = random error. The statistical analysis was computed using analysis of variance procedure described in the SAS (1993). Significance of differences between means were tested by the Multiple Range Test according to Duncan (1955).

Results

The animals were exposed to severe heat stress (THI = over 25.6) during most of the day (at 8.0 h = 25.22°C and relative humidity 45.36%, 12.00 h = 32.33°C and relative humidity and 16.00 h = 35.34°C and relative humidity 33.40%).

Tables 1-5 illustrate that lambs maintained on diets containing concentrate mixture without roughages surpassed those of the control group (fed diets containing roughages) in daily weight gain, economical and feed efficiencies, carcass weight, dressing percentage and lying time. However, contrary trends were shown in case of gut weight, eating time, rumination time, frequencies of drinking water, micturition, defecation, mounting and licking block minerals, rectal temperature and respiration rate.

The lambs given diets containing natural clay surpassed those given diets without natural clay in final weight, daily weight gain, economical and feed efficiencies, water intake, eating time, rumination time, lying time, frequencies of drinking water and mounting. Reverse trends were obtained in frequencies of defecation and licking block minerals, rectal temperature and respiration rate, with the same treatment.

The full concentrate mixture diet, without roughages plus natural clay, surpassed the other diets in final weight, daily weight gain, economical and feed efficiencies, dressing percentage and lying time. Contrary trends were obtained in case of empty gut weight, eating time, rumination time, frequencies of defecation, mounting licking block minerals and respiration rate with the same treatment. T3 was significantly lower in blood plasma of lambs given a diet containing full concentrate mixture alone than in the other diets. At the same time, plasma T4 in lambs fed diets containing concentrate mixture + roughages was significantly ($P < 0.01$) higher than in the other diets.

Discussion

Alleviation of the heat-stress may be achieved by ameliorating the environment, reducing the animal's heat production and/or helping the animals to dissipate the heat load. The latter category includes physical, physiological and nutritional techniques (Marai and Habeeb, 1997). Such techniques aim to correct the animal's negative balances, i.e., to keep the relative physiological changes to a minimum. Feeding full concentrate ration or natural clay dietary supplementation may be considered such nutritional technique.

The increase in daily weight gain, economic efficiency and dressing percentage

Table 5. Least squares mean (\pm S.E.) of some physiological reactions of male fattened lambs as affected by type of feeding during April-July months

Parameter (Treatments)	Rectal temperature ($^{\circ}$ C)	Respiration rate (Respirations/minute)	T3 (μ g/ml)	T4 (μ g/ml)
Natural clay effect (N)				
Diet without clay	39.3 ^a \pm 0.02	93.9 ^a \pm 0.1	113.0 \pm 5.7	7.7 \pm 0.3
Diets with clay	39.2 ^b \pm 0.02	87.0 ^b \pm 1.0	126.0 \pm 5.7	6.9 \pm 0.3
Significance	*	**	NS	NS
Concentrate mixture (C)				
Diets with roughages	39.4 ^a \pm 0.02	99.6 \pm 1.0 ^a	126.1 \pm 5.7	7.7 \pm 0.3
Diets without roughages	39.1 ^b \pm 0.02	81.3 \pm 1.0 ^b	112.2 \pm 5.7	6.9 \pm 0.3
Significance	**	**	NS	NS
Interactions (Nx C)				
C + roughages (Control)	39.4 ^a \pm 0.04	192.7 ^a \pm 1.7	127.6 ^a \pm 8.0	8.6 ^a \pm 0.5
C + roughages + clay	39.3 ^a \pm 0.04	96.3 ^b \pm 1.7	124.6 ^a \pm 8.0	6.8 ^b \pm 0.5
C only	39.2 ^b \pm 0.04	84.9 ^c \pm 1.7	98.3 ^b \pm 8.0	6.8 ^b \pm 0.5
C + clay	39.1 ^b \pm 0.04	77.6 ^d \pm 1.7	126.1 ^a \pm 8.0	7.0 ^{ab} \pm 0.5
Significant	NS	NS	NS	NS

Mean bearing different letter within the same classification, differ significantly ($P < 0.05$).

** $P < 0.01$; * $P < 0.05$; NS = Not significant; Economic efficiency = Economical efficiency relatively to control (%).

with the diet containing full concentrate mixture (without roughages) may be due to the high daily dry matter intake, or in other words, to the increase in daily protein intake as that reported by El-Hommosi and Abdel-Hafez (1979) and El-Serafy (1990). The increase in lying time with the same diet (concentrate mixture without roughages) may help in saving the energy otherwise consumed by animals in movements. This was also reflected in the increase in the growth rate. The less time taken in eating diet without roughages is expected, since it requires considerably less chewing than diets rich in fiber content. The low rumination time in lambs fed concentrate mixture, without roughages, may be due to the low fiber content in the diet, as Welsh and Smith (1979) reported that rumination time and number of chews and number of boluses were significantly high with the increase in hay intake level. The low daily water consumption in lambs given diets without roughages may be due to decrease in crude fiber content in the diet. The low rectal temperature and respiration rate in lambs fed concentrate mixture only may be due to low energy expenditure in the digestive process. More heat is produced as a result of digestion of diets high in roughages (Conrad, 1985). Similar results were found by Borady *et al.* (1984). These results suggest to improve performance of animals in the hot climate, animals need to be given concentrate mixture or feeds low in fiber content. The decrease in plasma T3 in lambs given concentrate mixture only, than the diets containing concentrate mixture + roughages may be due to the increase in the energy level or carbohydrate content as reported by Otten *et al.* (1980), Hagen (1983) and Shalaby and Shehata (1995).

The effects of natural clay might be related to its role in decreasing the rate of passage of the digesta and increasing of ion exchange capacity (Grim, 1968), digestibility of nutrients (El-Hakim *et al.*, 1994), reaction with dietary protein forming a complex that reduces protein degradability in rumen and improvement of nitrogen utilization (Britton, *et al.*, 1978 and Ayyat and Marai, 1997). These were reflected in improvement of daily weight gain and economic and feed efficiencies. The increase in eating time, rumination time and lying time in animals maintained on diets containing natural clay may mean that the animals became more calm, that might decrease their heat production and save the energy consumed in animal movements. The consequent results could be reduction in rectal temperature and respiration rate and increase in feed efficiency and average daily weight gain, which occurred in the present study. In short, improvement of digestibility and metabolism and retention of nutrients due to use of natural clay as dietary supplement (Pulatov *et al.*, 1983; Kalyuzhnov *et al.*, 1988; El-Gendy *et al.*, 1993; El-Hakim *et al.*, 1993; Kirilov and Bunkhonov, 1993 and Ayyat and Marai, 1997), helped in improvement in performance of the heat-stressed fattening lambs.

In conclusion, the use of a diet containing concentrate mixture plus local clay (@ 6 kg per 100 kg ration *ad libitum*) may improve the growth of the heat-stressed fattening lambs under Egyptian summer conditions.

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