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ENERGY PARTITIONING AND TISSUE RESPIRATORY METABOLISM OF LAYING CHICKENS REARED UNDER SUMMER CONDITIONS OF EGYPT*

By

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ABSTRACT: *A total number of 156 laying chickens at 29 weeks of age were used in the study. Birds were distributed equally in two dietary energy levels (2600 and 2900 Kcal ME/Kg feed) and three strains viz., Lohmann Selected Leghorn (LSL), Fayoumi and Dandarawi. Three experiments were conducted to measure energy partitioning values (36 birds), liver oxygen consumption and oxygen consumption of epithelium lining of magnum and shell gland (48 birds) and thermoregulation (72 birds).*

Dietary energy level had significant effect on apparent metabolizable energy (AME), the energy needed for maintenance and physiological work (MPWE) and liver oxygen consumption. Effect of dietary energy level was not significant on egg production performance, energy intake (EI), excreta energy (ExE), egg energy (EE) and physiological variables.

Strain effect was significant on all energy partitioning variables, liver oxygen consumption, percent of change of cloacal temperature, skin temperature and egg production performance. The strain of higher production performance (LSL) had higher energy intake (EI), excreta energy (ExE), apparent metabolizable energy (AME), the energy needed for maintenance and physiological work (MPWE) and egg energy (EE). Dandarawi showed higher liver oxygen consumption, epithelium lining of magnum and shell gland. In addition, Dandarawi showed highest percent of change of cloacal temperature. It was concluded that Dandarawi and Fayoumi seemed to be energy wasting birds but with different models.

INTRODUCTION

Energy is the fuel that drives all biological activities including egg laying. Energy is not a nutrient, but a property of energy-yielding nutrients oxidized during metabolism (Jalal, 2003). Approximately 90% of the total ATP from the complete oxidation of glucose to carbon dioxide and water is generated by mitochondria via oxidative phosphorylation (Lehninger *et al.*, 1993). Which amountes 90% of the energy needed for body cells (Iqbal *et al.*, 2005).

Cell metabolism is dependent on the nuclear and mitochondrial genetic systems and their interaction. It is well known that genetic and diet have profound influences over mitochondrial function. For example, differences in hepatic oxygen utilization rates between breeds of chicken had been observed (Mukherjee *et al.*, 1970). Mitochondria have been hypothesized to be part of the basis of heterosis in chicken (Brown *et al.*, 1986). Dietary manipulation of fat and protein have been shown to have effects on mitochondrial function (Toyomizu *et al.*, 1992). Recent evidences suggest that mitochondria function may be associated with feed efficiency in broilers (Iqbal *et al.*, 2004).

Egg production is high energy consuming process. To produce an egg, high calorific value compounds of yolk are synthesized in liver, mobilized via blood, and accumulated in ovarian follicles. This is followed by ovulation, protein synthesis and secretion in magnum, and overnight calcium precipitation in eggshell against calcium gradient which is high energy demanding process. The epithelial layer of shell gland has an extremely high rate of respiration and its mitochondria are active in accumulating calcium and phosphate (Lehninger, 1977). The mobility of ovum and expelling the egg involve muscular activity. All these events of egg formation are under hormonal and nervous control.

To improve egg production, energy utilization for egg production processes should be improved to be highly efficient. Very few reports are available for metabolic rate and cellular metabolism of native Egyptian strains. Heat production, estimated by calorimetic technique, of laying Fayoumi compared to LSL was done by Shoukry (1987) or compared to White Leghorn by Komiyama (1979). Shoukry (1987) has also estimated cytochrome oxidase activity and protein synthesis in secretory lining of magnum and shell gland of Fayoumi layers compared to their LSL peers.

Hyperthermia causes physiological dysfunction that may result in a decline in laying performance. In chicken, oxidative stress was observed on exposure to acute heart stress (Lin *et al.*, 2006). Wilson (1982) claimed that more information were needed on the energy costs of heat dissipation at higher temperatures and the presence of stress mechanisms that limit egg production at high environmental temperatures.

It is needed to accumulate large amount of information of energy dissemination and cellular metabolism of native Egyptian chickens to be available to geneticist to achieve breakthrough for improving their egg production. Therefore this study was conducted to estimate the value of disseminated energy in the laying chickens, cellular metabolism of oviduct epithelium and diurnal changes in body temperature.

MATERIALS AND METHODES

This study was conducted in Avian Surgery and Bioenergetics Lab., Poultry Experimental Station, Faculty of Agriculture, Al-Azhar University, Nasser City, Cairo, Egypt during the period from July 6th to September 24th, 2006.

Three strains of chickens were used in the present study, Lohmann Selected Leghorn (LSL) which is a Single Comb White Leghorn commercial strain, Fayoumi and Dandarawi as Egyptian native strains. The LSL chickens were obtained from Wadi Holdings S.A.E Company, Egypt. Fayoumi and Dandarawi chickens were obtained from the stock maintained in the poultry experimental station, Faculty of Agriculture, Al-Azhar University. The study was executed in three experiments.

Experimental birds and management of the flock:

Day old LSL chicks were brought to poultry experimental station on the same hatching day of their peers of the other two native strains. All chicks were reared on floor pens on standard layer grower diets according to (N.R.C., 1994). Standard photo regime of growing laying flocks was followed during rearing period. At 20 weeks of age birds were switched to experimental diets and transferred to individual cages for subsequent experimentation. A photo period of 16 L:8 D was followed during laying period. Birds had free access to feed and water.

The experimental diets were formulated to contain 18 % crud protein with calculated metabolizable energy levels of 2600 or 2900 Kcal ME/Kg feed. The composition of the layer diets is presented in table (1). All birds were healthy and clinical. They were vaccinated on a standard vaccination schedule.

Energy partitioning experiment:

Experimental design:

The experiment was designed to investigate the effect of two dietary energy levels fed to three strains (LSL, Fayoumi and Dandarawi) on partitioning of energy of chicken diets during summer season. A total number of 36 adult pullets aged 29 weeks were used. The birds were randomly and equally distributed to the experimental cells, with 6 birds each.

Table (1): Composition of the experimental diets.

Ingredients	Below-standard energy level (K cal ME/Kg diet)	Standard[1] energy level (K cal ME/Kg diet)
	2600	**2900**
Ground yellow corn 8.5%	57.55	63.35
Soybean meal 44%	14.9	17
Wheat bran 15.7%	10	-
Layer concentrate 50%[2]	10	10.1
Limestone	7	6.9
Vitamin and mineral premix[3]	0.3	0.3
Sodium Chloride	0.25	0.25
Sunflower Oil	-	2.1
Total (Kg)	**100**	**100**
Calculated Analysis		
Crud protein%	18.02	17.91
ME.Kcal/Kg feed	2599.2	2897.23
Calcium%	3.50	3.47
Available Ph.%	0.40	0.39
C/P ratio	144.23	161.77
Lysine%	0.83	0.84
Methionine + Cystin%	0.68	0.67

[1]N.R.C. dietary energy standard for White layer strains.

[2]**Composition of layer concentrate**: contain Crud protein 50%, Crud fiber 1.8%, Calcium 7.8%, Available Ph. 2.88%, Methionine 1.23 %, Methionine + Cystine 2.15%, Lysine 2.17%, Sodium 1.69 % and ME 2090 Kcal.

[3]**Composition of vitamin and mineral premix.** Each 3Kg of vitamin and minerals mixture contain: Vit. A 10,000,000 IU, Vit. D_3 2,000,000 IU, Vit. E 10,000 mg, Vit. K_3 1,000 mg Vit. B_1 1,000 mg, Vit. B_2 5,000 mg, Vit. B_6 1,500 mg, Vit B_{12} 10 mg, Niacin 20,000 mg, Pantothenic acid 10,000 mg, Folic acid 1,000 mg, Biotin 50 mg, Choline chloride 500,000 mg, Copper 4,000 mg, Iodine 300 mg, Iron 30,000 mg, Manganese 60,000 mg, Zinc 50,000 mg, Cobalt 100 mg and Selenium 100 mg.

Procedures of the experiment:

Birds were individually housed in cages that specially designed and constructed to retain droppings. Digestibility experiments were performed according to Anne Bourdillon *et al.*, (1990) as follows;

a) Preliminary period: Birds were fed *ad libitum* the experimental diets for 72 hours then feed consumption was restricted to 0.90 of *ad libitum* for another 55 hours, the restriction was implemented in order to minimize ingredient selection in feeders.

b) Digestion trial: this trial lasted for 5 days during which the birds were fed 0.90 of *ad libitum.* Feed intake, body weight and egg mass output were recorded through the whole experimental period. Excreta and eggs were collected for every individual bird. Excreta were cleaned from feathers and scattered feed before stored. Samples of diet and excreta were immediately stored at -20°C in sealed aluminum dishes, then oven-dried on 80 °C for 48 hours. Eggs of each hen were broken and homogenized with Sonecator (MSE-England) at 28 db for 15 minutes afterwards they were dried on 60°C under vacuum for 6 hours until their weights were constant. Diet, excreta and egg samples of each bird were used for assaying energy content. The dried excreta, eggs and feeds were grounded by blender to fine particles and preserved dried in labeled plastic bags, then stored in a deep freezer at approximately -20°C until analysis. Gross energy values for feed, excreta and eggs were determined by adiabatic bomb calorimeter (Model 1261, PARR-England) at Regional Center for Food and Feed (RCFF), Agricultural Researches Center (ARC), Egypt. Chemical composition of the dry whole egg for crude protein (CP), ether extract and ash were determined according to methods described by AOAC (1990).

The schema of energy partitioning followed in the present study is illustrated in figure (1) according to (Luiting, 1990).

Environmental data:

Dry and wet bulb ambient temperatures were recorded to the nearest 0.01°C inside the chicken house using Psychrometer. Temperatures were recorded daily at 9 a.m and 2 p.m. Relative humidity was obtained from Psychrometer chart according to (Esmay, 1978). Averages of dry and wet bulb temperatures and relative humidity at 9 a.m. were 28.20°C, 26.09 °C and 84.99 %, respectively, and at 2 p.m. were 32.00°C, 27.20 °C and 70.10 %, respectively.

Statistical analysis:

Two-way analysis of variance was used to test the effects of dietary energy levels, strains and their interaction. Least squares means were used to compare means at the level of ($P \leq 0.05$) according to (Winer, 1971). The statistical analysis of data was carried out by applying the software package of SAS (1988) using GLM procedure and least squares means for mean separations.

Tissue respiratory metabolism experiment:

Experimental design:

A total number of 48 laying hens aged 29 weeks were used in the experiment. They were distributed equally and randomly on three strains (LSL, Fayoumi and Dandarawi) strains, two dietary energy levels (2600 or 2900 Kcal ME/ Kg feed) and 4 replicates.

Procedure of the experiment:

Samples of liver and epithelium lining of magnum and shell gland in the experiment were obtained to measure oxygen consumption. Oxygen consumption was measured using constant volume manometry technique by Warburg apparatus. Birds were slaughtered. Apex of right liver lobe was sampled and the epithelium lining of magnum and shell gland were scraped by scalpel. All tissue samples were in contact with ice until analysis. The analysis was done within 30 minutes of tissue sampling. A total volume of 2.5 ml of Hanks media (Wasley, 1972) and tissue sample was placed in the flask of Warburg apparatus and a strap of filter paper saturated with 30% KOH was put in the well of the flask. The reading of the manometer was recorded after one hour of incubation on 30°C to determine the O_2 consumed by the tested tissue, according to Umbreit *et al.*, (1972). For the sake of standardizing physiological status of oviduct, all data of birds with hard shells ova were considered otherwise data were discarded. All measurements were calculated on the dry sample basis.

Environmental data:

Dry and wet bulb temperatures were performed the same as energy partitioning experiment. Data were also collected in the same periods of day.

Statistical analysis:

Statistical analysis was performed the same way as energy partitioning experiment.

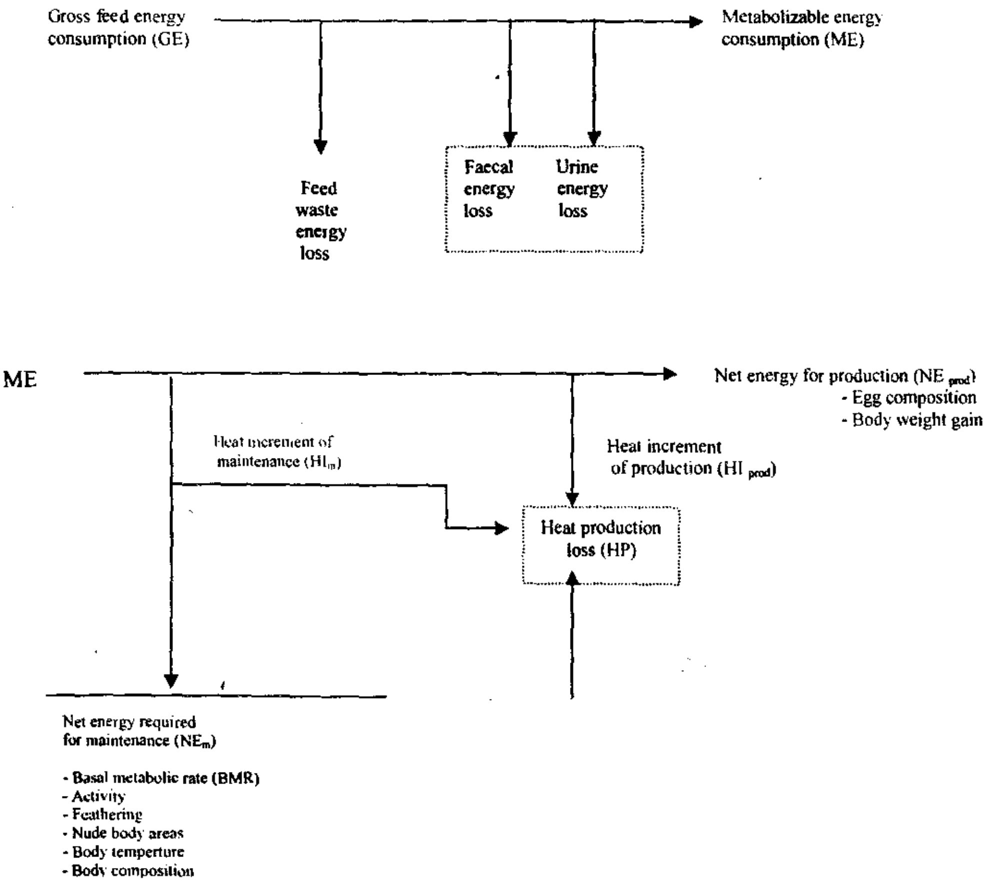

Figure (1): The flow of gross energy consumption over the various energy demanding processes in laying hens (Luiting, 1990).

Thermoregulation experiment:

Experimental design and procedure:

Seventy two laying chickens were assigned equaling and randomly into experimental groups. The experimental groups were two dietary energy levels, 3 strains and 4 replicates. Cloacal temperature, skin temperature and respiration rate were measured on the same bird at 4 a.m. and 3 p.m. in the same day. Measurements were repeated in two consecutive days. Two electronic thermometers with 0.1°C resolution were used at a time for measuring cloacal temperature by inserting the probe 2-cm deep in contact with the inner cloacal wall. The other probe was put in contact with the skin under the right wing for 1 minute. Respiration rate was taken by counting the movements of body wall for one minute.

Environematal data:

Dry and wet bulb ambient temperatures in °C were recorded inside the chicken house using Psychrometer. Temperatures were recorded daily at 4 a.m and 3 p.m. Relative humidity was obtained from Psychrometer chart according to (Esmay, 1978). The averages of dry and wet bulb temperatures and relative humidity at 4 a.m were 25.91°C, 20.77 °C and 64.20 %, respectively, and were 32.66°C, 28.63 °C and 74.96 % at 3 p.m., respectively.

Statistical analysis:

Three-way analysis of variance repeated in one way (Split plot in time) was used to test the effects of two dietary energy levels, three strains and two periods of time (repeated). Least squares means were used to compare means at the level of ($P \leq 0.05$) according to (Winer, 1971). The statistical analysis of data was carried out by applying the software package of SAS (1988) using GLM procedure and least squares means for mean separations.

RESULTS AND DISCUSSION

Energy Partitioning:

Feeding standard dietary energy level (2900 Kcal ME/Kg feed) or below standard level (2600 Kcal ME/Kg feed) to the three strains of chickens revealed that no significant effects of the dietary levels on energy intake (EI), excreta energy (ExE) and (EE) egg energy if results were calculated for bird (absolute energy) or even for kg metabolic body size (relative energy) as shown in table (2). Energy intake was insignificantly low in 2600-group compared to the other 2900-group. Similar finding was reported by El Jack and Blum (1978) in laying hens reared in high environmental temperature. Meanwhile, dietary energy level had significant effect ($P \leq 0.05$) on absolute energy of apparent metabolizable energy (AME) and the energy needed for maintenance and physiological work (MPWE), however, when data were calculated for kg metabolic body size no significant effect of dietary energy level was noticed on AME but it showed significant effect on MPWE (Table,2). For the significantly affected variables even as absolute or relative energy, the dietary level 2600-group showed higher values compared with the 2900-group.

Regardless of the effect of dietary energy, strain effect on the metabolic avenues of dietary energy was expectedly significant (Table, 2). It is well noticed that the absolute or relative values of EI, ExE, AME, and EE of LSL chickens were always significantly higher ($P \leq 0.05$) than those of Dandarawi chickens (Table, 2). Concerning MPWE values, LSL chickens showed significantly higher ($P \leq 0.05$) absolute values than that of Dandarawi chickens, however, the differences of relative values were not significant (Table, 2).

Fayoumi chickens showed inconsistent trend. The absolute energy values of EI, and AME of Fayoumi chickens were significantly lower ($P \leq 0.05$) than those of LSL and significantly higher ($P \leq 0.05$) than those of Dandarawi (Table, 2). Meanwhile, the absolute energy values of ExE, and MPWE of Fayoumi chickens differ insignificantly with those noticed by LSL. The same trend was found for relative values of EI, EE, AME, and MPWE (Table, 2). Fasting heat production of laying Fayoumi was significantly lower than that of LSL where their values were 3.562 and 4.198 Kcal/$BWT^{0.75}$.h, respectively as found by Shoukry (1987). In addition, maintenance requirement is a function of metabolic body size (Jalal, 2003). This indicated that the energy needed for maintenance of LSL layers was higher than that of Fayoumi. This supports the present study, where metabolic body size of LSL was higher than that of Fayoumi and Dandarawi.

Comparing Fayoumi variables with those of Dandarawi revealed that the absolute values of MPWE, and EE in Fayoumi differ insignificantly than those of Dandarawi. The former trend was noticed also in the relative energy values viz., EI, ExE, AME, MPWE, and EE. Excreta energy absolute value was significantly higher ($P \leq 0.05$) in Fayoumi compared to that of Dandarawi (Table, 2).

As general trend no matter how differences are significant or not in all energy values in the study, studied strains could be ranked as LSL the highest followed by Fayoumi then Dandarawi. This was noticed even when the energy values were calculated per bird (absolute values) or corrected for metabolic body size (relative values). Similar rank was also noticed for egg mass output and body weight (Table, 3). It seems that reproductive activity (egg mass output) had imposed greater effect than body weight on different metabolic avenues as the correction to metabolic body size mostly did not eliminate the differences or changed the ranking of the strains. The inconsistency of Fayoumi values may reflect higher variability than those of LSL or Dandarawi as shown by its larger standard error of means (Table, 2).

Tissue respiratory metabolism, Thermoregulation, and laying performance:

Physiological work in the present study includes respiratory metabolism of liver and oviduct and thermoregulation. Values of oxygen consumption of oviduct portions in the present study were lower than those found by Beuving (1971) and Misra and Keměny (1964). The present study was concerned only with the epithelial lining of the oviduct, however, former authors used complete minced wall of the oviduct. Which were including muscular layers of oviduct. Feeding two dietary energy levels (2600 and 2900) did not significantly affect the oxygen consumption of epithelial lining of magnum and shell gland. The percent of change of cloacal temperature (Tc_pct), skin temperature (Ts_pct), and respiration rate (RR_pct) were not affected also by dietary energy level. The 2900-group showed significantly higher ($P \leq 0.05$) liver oxygen consumption than that of 2600-group (Table, 3). This finding supports the findings mentioned formerly as 2900-group had absolute values of AME and MPWE and relative values of MPWE significantly higher than those of 2600-group (Table, 2).

No significant differences were found among LSL, Fayoumi, and Dandarawi in oxygen consumption of epithelial lining of magnum and shell gland, however, Dandarawi had significantly higher ($P \leq 0.05$) liver oxygen consumption than those of Fayoumi and LSL (Table, 3). Liver oxygen consumption of LSL and Fayoumi did not differ significantly. Mukherjee *et al.*, (1970) found breed difference in hepatic oxygen consumption of week old chicks of White Leghorn, White Rock, and their cross, suggesting heterosis behavior of the genes controlling these criteria.

As general trend, no matter how differences are significant or not in all oxygen consumption values in the study, Dandarawi showed prominent highst values of oxygen consumption of liver and epithelial lining of magnum and shell gland (Table, 3). This indicates that Dandarawi spent more energy by oviduct secretory cells compared to the other two strains. All energy avenues of Dandarawi shown in table (2) are lower than those of LSL, however, liver oxygen consumption of Dandarawi is significantly higher than that of LSL.

Dandarawi had significantly higher ($P \leq 0.05$) Tc_pct and Ts_pct than those of Fayoumi. The percent of change of Tc and Ts of LSL did not differ significantly from each of Dandarawi and Fayoumi (Table, 3). No significant differences were found among the three strains in the RR_pct. Dandrawi showed also prominent values of Tc_pct and Ts_pct. The chickens of Dandarawi increased their cloacal and skin temperatures by 1.15 and 1.09%, respectively between 4 am and 3 pm on the same day (Table, 3). This may indicate that Dandarawi exert more energy as heat to raise its body temperature to cope with the increase of diurnal temperature than Fayoumi and LSL. This thermoregulatory mechanism is commonly known for birds of desert regions as a water conservation strategy (Dawson and Whittow, 2000).

It is noticed that Fayoumi and LSL chickens had similar tissue respiratory metabolism and thermoregulatory responses. However, Dandarawi showed distinct higher values than those of the two other strains. This finding may be biochemical and physiological evidences support the results of Ponsuksili *et al.*, (1999). Ponsuksili and his colleagues used microsatellite analysis to investigate genetic distances among 12 chicken populations. According to the microsatellite-based dendrogram tree developed in their study, they found that White Leghorn and Fayoumi were in the same cluster, however, Dandarawi was in another distant cluster. This indicts that, genetically speaking, Fayoumi and White Leghorn are closer together than Dandarawi.

Dietary energy level had no significant effect on all laying performance variables studied in the present work (Table, 2). Wu *et al.*, (2005) found that dietary energy increasing from 2719 to 2956 Kcal did not affect egg production and energy conversion (Kcal diet/ 1 g egg). Wu *et al.*, (2007) found that the increase of dietary energy from 2784 to 2887 Kcal/kg with different protein levels did not affect egg mass, feed intake, body weight, feed conversion, and energy intake for 1 g egg. El Jack and Blum (1978) reported that dietary energy did not affect egg production of laying hens reared in high environmental temperature.

In addition, strain effect was clear on body weigh (BWT), feed intake (FI), and egg mass output (EMO). For BWT and FI, all differences among strains were significant ($P \leq 0.05$). Lohmann Selected Leghorn chickens showed the highest BWT and FI, meanwhile Dandarawi peers were the least and Fayoumi had intermediate values (Table, 3). Lohmann Selected Leghorn had the best EMO. Egg mass output of LSL chickens was significantly higher ($P \leq 0.05$) than those of Dandarawi and Fayoumi peers. The difference between the two local strains in EMO was not significant. These findings matched the finding of absolute energy values of EI and AME in table (2). This indicates that birds in the present study were consuming feed and energy according to their metabolizable energy, laying status and, body weigh to get their maintenance, physiological, and production needs. Daily AME requirement of laying chicken was reported to be affected by maintenance, egg mass, growth, feather score and ambient temperature (Huyghebaert *et al.*, 1988).

Feed conversion (FC) was the worst for Fayoumi. Differences between Fayoumi and each of Dandarawi and LSL in FC were significant ($P \leq 0.05$). However, FC was insignificantly better for LSL than Dandarawi (Table, 3). Energetic efficiency (Eeff) of LSL was significantly ($P \leq 0.05$) better than that of Fayoumi and Dandarawi (Table, 3). These differences in energy utilization may be due to genetics of the bird, egg size and composition as reviewed by Zhang (1997). Dandrawi showed no significant difference from Fayoumi Eeff values (Table, 3), The AME energy needed to produce 1 kcal of whole dry egg were 2.3, 3.2, and 3.32 kcal for LSL, Fayoumi, and Dandarawi, respectively.

The fraction of Eeff of LSL is 0.43 energy utilization which is lower than the lowest value (0.49) reviewed by Zhang (1997). It is suggested that LSL expend more energy to cope with summer conditions which makes relatively less energy is available for production. In addition, heat stress reduces feed intake and the blood supply to reproductive and digestive systems which reduces the nutrients available for production (Wilson, 1982).

Strain significantly affected energy conversion (dietary Kcal/1g egg) as reported by Wu *et al.*, (2005). The differences in Eeff indicate that laying Fayoumi and Dandarawi are wasting more energy in avenues not related to net production. The prominent tissues oxygen consumption and lower FC and Eeff of Dandarawi compared to those of LSL, could be explained by the findings of Ojano-Dirain *et al.*, (2007), who reported that production of H_2O_2 is consistently observed in mitochondria from tissues of low feed efficient birds. They hypothesized that oxidative damage to respiratory chain protein subunits might be responsible, in part, for the reduced activities of the respiratory chain complexes in low feed efficient birds.

The inefficient energy utilization of Fayoumi could not be explained in the scope of the present study. Some reports dealt with hereditary nervous disorder in Fayoumi chickens (Nunoya *et al.*,1983). This disorder was represented as seizures of physical activity that consume energy. These seizures of Fayoumi are triggered by unexpected loud noise, sudden movement, sudden bright light and, other audiovisual stimuli (Fadlallah *et al.,* 1996, and, Nunoya *et al.*, 1983), which may be responsible for wasting its energy.

General Conclusion:

Increasing dietary energy from 2600 to 2900 Kcal/ Kg significantly increased the energy intake, meanwhile, feed intake stayed constant. El Jack and Blum (1978) found similar trend working under the same environmental temperature (32 °C). However, this trend is different than that found by Wu *et al.*, (2005 and 2007) where the birds in their studies changed their food intake to get constant energy intake. Wu and his colleagues performed their studies in constant environmental temperature (25.6 °C).

It seems that high ambient temperature affect laying chickens to change their energy and feed intakes. Wilson (1982) reported that laying chickens reduced their feed and energy intakes in high ambient temperature when energy was lowered in the diet. Feeding high energy diets under high environmental temperature did not improve egg laying performance. He reported that at 32 °C ambient temperature, laying chicken needs 200Kcal/day to support 80% egg production, meanwhile, 280 Kcal/day is needed at 21 °C to attain the same level of production.

Lower ME, efficient feed conversion, and lower body weight were in part due to lower maintenance required for line of White Leghorn compared to other lines within the same strain Sabri *et al.*, (1991). This relationship gives an interpretation for differences among lines but may not valid for differences among strains. On the other hand, as mentioned formerly maintenance requirement is greater in large than in small birds. In the present study LSL chickens had larger body weigh than the other two strains, in addition LSL had higher fasting heat production than that of Fayoumi (Shoukry, 1987). This may elucidate the higher AME consumption of LSL to produce eggs with higher energy content. The energetic efficiency of LSL was better than those of Fayoumi and Dandarawi (Table, 3), however, the values of relative AME as fraction of EI almost the same of the three strains, 0.786, 0.776 and, 0.782 for LSL, Fayoumi and, Dandarawi, respectively. This indicates that the egg production machinery of LSL derived the AME energy for egg production more efficiently.

In the present study all strains utilized energy of feeds according to their genetic make-ups regardless of dietary energy content as the interaction between dietary energy and strain was not significant. The genetic difference in the present study concerning Eeff is supported by findings of Harms *et al.*, (2000). In they study the energy required to produce 1g of egg content was always lower for the light group regardless of the basis of selection.

It could be concluded that Fayoumi and Dandarawi strains were energy wasting birds as they consumed 3.2 and 3.3 Kcal AME to produce 1 Kcal of whole dry egg, respectively. This is significantly higher compared to LSL the better energy utilizing strain that consumed 2.3 Kcal AME to produce 1 Kcal of whole dry egg. It was noticed that Fayoumi and Dandarawi the native Egyptian strains adapted for the summer of sub tropical zone, disseminated energy in their bodies in two different models. This may reflect their genetic diversity. Dandarawi expended more energy in thermoregulation and inefficient cellular respiration. However, Fayoumi seems to spend more energy in avenues not related to production, thermoregulation or cellular respiration. The nervous physical activity could be one of these avenues of wasting energy of Fayoumi. Komiyama *et al.*, (1979) found that respiratory quotient of Fayoumi layers was significantly higher than that of White Leghorn, however, their heat production did not differ significantly. This could be an evidence of more physical activity of Fayoumi. Figure (2) illustrates energy partitioning related to the reproduction as modified from Wade (1998). The values of the present study were applied on the chart.

It is suggested that the two native strains need more studies on energy metabolism and cellular metabolism to improve their genetic capability to utilize energy more efficiently which may improve their egg production.

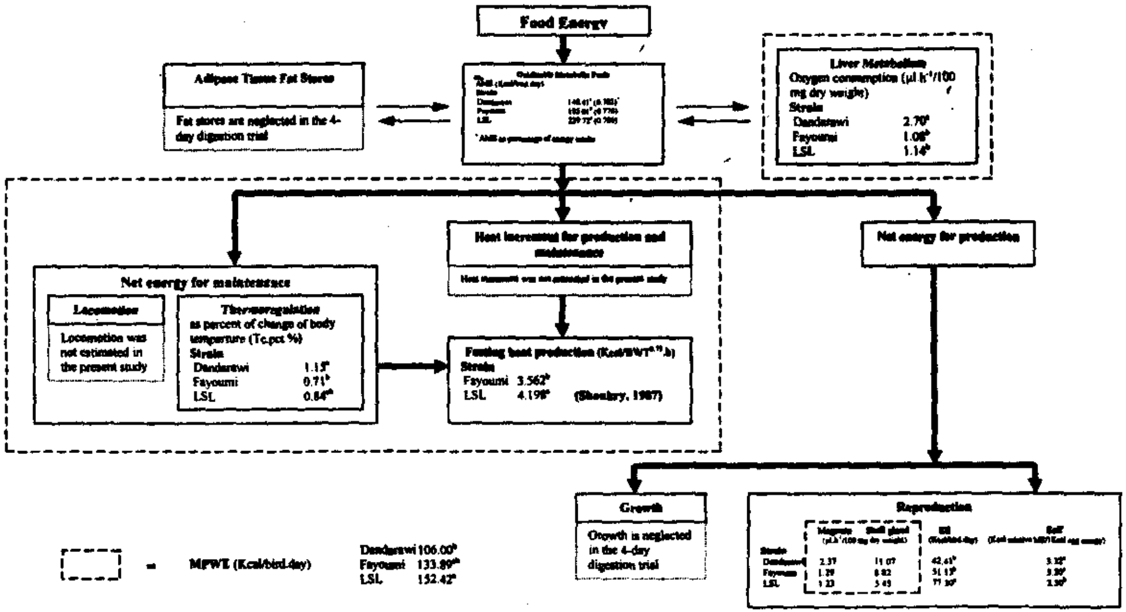

Figure (2): Partitioning of metabolic fuels for reproduction is modified from Wade (1998) according to energy flow adapted by present study and applied to the values obtained.

AME = Apparent Metabolizable Energy, MPWE = Maintenance & Physiological Work Energy, EE = Egg Energy, Eeff = Energetic efficiency.

Table (2) Absolute energy (Kcal/bird.day) and relative energy ($Kcal/Kg^{0.75}$.day) of laying chickens fed different levels of dietary energy at 29 weeks of age.

Main Effects	Absolute Energy (Kcal/bird.day)					Relative Energy ($Kcal/Kg^{0.75}$.day)				
	EI	ExE	AME	MPWE	EE	EI	ExE	AME	MPWE	EE
Dietary Energy(Kcal/Kg feed)										
2600	228.16±10.37[1]	53.65±2.54	$174.51^{B}\pm8.23$	$116.50^{B}\pm8.58$	58.01±2.69	189.34±8.97	44.50±2.12	144.83±7.14	$96.92^{B}\pm7.25$	47.91±2.41
2900	252.03±10.71	51.11±2.62	$200.92^{A}\pm8.50$	$145.03^{A}\pm8.86$	55.89±2.78	205.00±9.27	41.66±2.18	163.34±7.37	$118.09^{A}\pm7.49$	45.25±2.49
Strain										
Dandarawi	$189.86^{c}\pm12.71$	$41.46^{b}\pm3.11$	$148.41^{c}\pm10.07$	$106.00^{b}\pm10.50$	$42.41^{b}\pm3.29$	$173.26^{b}\pm10.99$	$37.78^{b}\pm2.59$	$135.48^{b}\pm8.74$	97.14±8.88	$38.34^{b}\pm2.95$
Fayoumi	$238.56^{b}\pm13.33$	$53.54^{b}\pm3.26$	$185.01^{b}\pm10.57$	$133.89^{ab}\pm11.02$	$51.13^{b}\pm3.45$	$195.49^{ab}\pm11.53$	$43.86^{ab}\pm2.72$	$151.63^{ab}\pm9.17$	109.62±9.32	$42.00^{b}\pm3.09$
L.S.L.	$291.86^{a}\pm12.71$	$62.14^{a}\pm3.11$	$229.72^{a}\pm10.07$	$152.42^{a}\pm10.50$	$77.30^{a}\pm3.29$	$222.76^{a}\pm10.99$	$47.61^{a}\pm2.59$	$175.15^{a}\pm8.74$	115.76±8.88	$59.39^{a}\pm2.95$
S.O.V										
MS	13844.88	533.77	9617.26	4341.88	1625.34	3442.68	147.46	2599.37	1314.50	623.98
Df	34	34	34	34	34	34	34	34	34	34
Residual	1937.26	115.89	1217.85	1324.19	130.02	1449.16	80.52	917.27	946.65	104.21
P	0.0002	0.0033	0.0001	0.0181	0.0001	0.0635	0.1379	0.0334	0.2576	0.0006

EI= Energy Intake, ExE = Excreta Energy, AME = Apparent Metabolizable Energy, MPWE = Maintenance & Physiological Work Energy, EE = Egg Energy.

[1]Least squares means ± pooled standard error.

[a,b,c] Means having different letter exponents among strains are significantly different ($P\leq0.05$).

[A,B] Means having different letter exponents between dietary energy are significantly different ($P\leq0.05$).

Table (3) Physiological work and laying performance of laying chickens fed different levels of dietary energy at 29 weeks of age.

Main Effects	Physiological work						Laying Performance				
	Oxygen Consumption (µl . h^{-1}/100 mg dry weight)			Thermoregulation As Percent of Change (%)							
	Liver	Magnum	Shell gland	Tc.pct	Ts.pct	RR.pct	BWT (Kg)	FI (g/bird.day)	Egg mass output (g/bird.day)	FC (g feed/1g eggs)	Eeff (Kcal relative ME/1Kcal egg energy
Dietary Energy(Kcal/Kg feed)											
2600	1.19^{B}±0.32^{1}	1.67±0.44	6.63±2.52	0.81±0.10	0.78±0.09	4.76±2.99	1.28±0.03	63.58±2.82	37.30±1.37	1.85±0.13	2.81±0 23
2900	2.09^{A}±0 26	1.59±0.35	10.26±2.04	0 99±0.10	0.93±0.09	10.65±2.99	1.32±0.03	66.80±2.92	37.10±1.42	1.89±0.13	3.07±0.24
Strain											
Dandarawi	2.70^{a}±0.35	2.37±0.48	11.07±2.74	1.15^{a}±0.12	1.09^{a}±0.11	8.13±3.66	1.15^{c}±0.04	51.56^{c}±3.46	27.42^{b}±1.68	1.95^{b}±0.16	3.32^{a}±0.28
Fayoumi	1.08^{b}±0.42	1.29±0.57	8.82±3.29	0.71^{b}±0.12	0.63^{b}±0.11	7.87±3.66	1.31^{b}±0.04	64.82^{b}±3.63	31.86^{b}±1.77	2.15^{a}±0.17	3.20^{a}±0.29
L.S.L.	1.14^{b}±0.29	1.23±0.40	5.45±2.30	0.84^{ab}±0.12	0.85^{ab}±0.11	7.11±3.66	1.43^{a}±0.04	79.20^{a}±3.46	52.31^{a}±1.68	1.52^{b}±0.16	2.30^{b}±0.28
S.O.V											
MS	2.03	1.21	34.56	1.16	1.12	338.88	0.11	955.52	857.04	0.54	1.86
Df	17	17	17	143	143	143	34	34	34	34	34
Residual	0.59	1.09	36.12	0.72	0.62	641.98	0.02	143.46	34.01	0.31	0.95
P	0.0373	0 4063	0.4807	0.1234	0.0800	0.8339	0.0011	0.0003	0.0001	0.1546	0.1140

Tc = Cloacal Temperature, Ts = Skin Temperature, RR = Respiration Rate, BWT = Body Weight, FI = Feed Intake, FC = Feed Conversion, Eeff = Energetic efficiency.

[1]Least squares means ± pooled standard error.

[a,b,c] Means having different letter exponents among strains are significantly different ($P \leq 0.05$).

[A,B] Means having different letter exponents between dietary energy are significantly different ($P \leq 0.05$).

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الملخص العربى

تجزئة الطاقة والتمثيل التنفسى للانسجة للدجاج البياض المربى تحت ظروف الصيف بمصر

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استخدم فى هذه الدراسة عدد ١٥٦ دجاجة بياضة عمر ٢٩ اسبوع. تم توزيع الطيور بتساوى على مستويين من الطاقة وهما ٢٦٠٠ و ٢٩٠٠ كيلو كالورى طاقة ممثلة/كجم غذاء وثلاثة سلالات وهما كتالى ل.س.ل والفيومى والدندراوى. تم تنفيذ ثلاث تجارب لقياس قيم اجزاء الطاقة (٣٦ طائر) ولقياس الاكسجين المستهلك للكبد وكذلك الاكسجين المستهلك للطبقة الطلائية المبطنة للمعظم وغدة القشرة (٤٨ طائر) ولقياس التنظيم الحرارى (٧٢ طائر).

ودلت النتائج على إن مستوى الطاقة فى الغذاء كان له تاثير معنوى على كل من الطاقة الممثلة الظاهرية والطاقة اللازمة لحفظ الحياة والعمل الفسيولوجى وكذلك الاكسجين المستهلك للكبد. ولكن كان لمستوى الطاقة فى الغذاء تاثير غير معنوى على كل من انتاج البيض والطاقة الماكولة وطاقة الزرق وطاقة البيض والمتغيرات الفسيولوجية.

تاثير السلالة كان معنويا على كل المتغيرات الخاصة باجزاء الطاقة والاكسجين المستهلك للكبد و النسبة المئوية للتغيرات اليومية لحرارة الجسم والجلد وكذلك انتاج البيض. لوحظ ارتفاع قيم كل من الطاقة الماكولة وطاقة الزرق و الطاقة الممثلة الظاهرية والطاقة اللازمة لحفظ الحياة والعمل الفسيولوجى وطاقة البيض لسلالة ل.س.ل ذات الانتاج المرتفع. اما سلالة الدندراوى فلوحظ ارتفاع قيم الاكسجين المستهلك للكبد وكذلك الاكسجين المستهلك للطبقة الطلائية المبطنة للمعظم وغدة القشرة وايضا ارتفاع النسبة المئوية للتغيرات اليومية لحرارة الجسم. اظهرت النتائج ان الدندراوي والفيومى طيور مهدره للطاقة ولكن بأساليب مختلفة.