



# Evaluation of Using Honey, Cool Water and Levamisole against Heat Stress on Different Traits of Rabbits under Egyptian Summer Conditions

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## ABSTRACT

This study was conducted in order to estimate the impact of using honey in drinking water, drinking cool water and Levamisole injection as alleviated tools of heat stress on White New Zealand rabbits under Egyptian summer conditions. 40 sexually mature White New Zealand rabbits contained 36 does with an average age of 15-20 (18±2) weeks and nearly similar body weight of 2 kg and 4 fertile bucks with an average age of 24 weeks and average weight of 2.5 kg were used in this experiment. They were allocated into four groups each containing 9 does and 1 buck. Group I was kept as a control without any treatment, group II received honey 20 ml/l on drinking water, group III drank cold water with a temperature ranged from 16-20 °C and group IV received a single dose of subcutaneous Levamisole injection (2 mg/kg BW). Results showed that most of performance, reproductive and physiological parameters of examined rabbits were significantly decreased by heat stress under Egyptian summer conditions. However, treated groups showed improved traits on most examined parameters comparing with control group. Among the treated groups, the one treated with honey expressed significant increase (P<0.05) in body weight, body weight gain, feed intake, feed conversion ratio, water consumption, conception rate, litter size and weight, milk yield, economic efficiency, rectal temperature, hematological parameters and some serum biochemical parameters. On the other hand, the group which received cool water showed the best records for decreased levels of serum urea, creatine and respiratory rate. In conclusion, it is clear that heat stress has negative effects on reproductive and physiological traits of growing rabbits with drawing attention toward the importance of using alleviating methods for mitigating the negative effects of heat stress especially by using honey and drinking cool water.

**Key words:** Heat stress, Honey, Cool water, Levamisole, Rabbit traits

## INTRODUCTION

Commercial rabbit production has been gaining much attention in recent years due to its high prolificacy, rapid growth rate, small body size and high meat yields (Marai et al., 1999). Rabbits can convert 20% of protein they eat into edible meat which is higher than pigs (16-18%) and beef (8-12%) (Basavaraj et al., 2011). Heat stress is defined as a stress inflicted by a wide range of environmental conditions that induce a state of physiological problems within animal's body, makes animals unable to regulate their heat homeostasis passively (Askar and Ismail, 2012). Heat stress is the most obvious limitation to rabbit production in regions with a hot climate (Ondruska et al., 2011).

Egypt climate is characterized by a long hot period (from May to October); in this period rabbits have difficulty in eliminating their body heat due to their nonfunctional sweat glands (Marai et al., 1994a, 1994b and 1996). Thermal Neutral Zone (TNZ) temperature in rabbits is around 18–21 °C (Marai and Habeeb, 1994; Habeeb et al., 1998). Keeping the growing animals under high ambient temperature (above 30°C) deleteriously affects their growth performance traits (Habeeb et al., 1992). Furthermore, disturbances in feed intake, feed utilization, water metabolism, blood parameters, and enzymatic reactions, hormonal secretions, in addition to protein, energy and mineral imbalances have been also reported to be disrupted in heat stressed rabbits (Okab and El-Banna, 2003; El-Banna et al., 2005; Burnett et al., 2006 and Okab et al., 2008). Additionally, heat stress negatively affects rabbit's production (Fouad, 2005). Many attempts have been established in order to overcome the detrimental effects of heat stress on growing rabbits, via modifying environmental condition through nutritional, managerial, and physiological manipulation of rabbits (Selim et al., 2003). Moreover, many additives are recently added to rabbit feed or water as a way to help alleviate adverse effect during summer months in a trial to keep the animal within the range of its thermo neutral state that realize comfort, as well as enhance productive performance and immune response of rabbits. Honey is a sweet liquid made by bees using nectar

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from flowers, it has high levels of monosaccharides, fructose and glucose, containing about 70 to 80 % sugar, which gives its sweet taste, minerals and water make up the rest of its composition (Graham, 1992).

Honey possesses antiseptic and antibacterial properties. Several studies have shown bee venom to exert both an anti-inflammatory effect, a property shared with non-steroidal anti-inflammatory drugs (Jang et al., 2003), and an antibacterial effect with no side effects in animal models (Han et al., 2006). Furthermore, apitherapy using live honeybee stings had therapeutic value for pigs with respiratory diseases such as atrophic rhinitis, pleuropneumonia, and Glasser's disease (Choi et al., 2003). In addition, providing cool water was found to be effective in alleviating the heat load of rabbits (Abd El Monem et al., 2013). Treatment of heat-stressed rabbits by drinking cool water (10-15 °C) showed the highest body weight, total body gain and margin percentage, as well as improved feed intake, feed conversion and decreased water intake (Marai et al., 1999).

Levamisole is a synthetic imidazothiazole derivative which is a highly acceptable antinematodal drug because of its broad range of activity in a large number of hosts (El-Boshy and El-Deean, 2013). Treatment of heat stressed rabbits by Levamisole showed a return in the increased RBCs count and stress leukogram picture to normal (El-Boshy and El-Deean, 2013). The drug is well absorbed and widely distributed and can be detected in all tissues and fluids with the highest levels in liver and kidneys (Madani et al., 2010). To our knowledge using the honey as a mitigating tool to alleviate the effect of heat stress on rabbits, as well as the effect of using cool water and Levamisole on some reproductive traits of heat stressed rabbits has not been investigated previously. Therefore, the objective of the present study was to investigate the effect of adding drinking water with honey, drinking cool water and injection of Levamisole on some reproductive, performance and physiological parameters of White New Zealand (WNZ) rabbits under Egyptian summer conditions.

## **MATERIAL AND METHODS**

### **Ethical approval**

Animal ethics committee, faculty of veterinary medicine, Kafr-Elsheikh University, Egypt, approved the protocol and conducting of the study.

### **General layout of experiment**

This study was carried out for 9 weeks (from 19th June till 21th August, 2015) at the laboratory of the department of hygiene and preventive medicine, faculty of veterinary medicine, Kafr El-Shiekh University, Egypt.

### **Animals and husbandry**

40 sexually mature WNZ rabbits 36 does with an average age of 15-20 (18±2) weeks and nearly similar body weight 2kg and 4 fertile bucks with an average age of 20-26 (24±2) weeks and average weight of 2.5 kg, which were proven to be fertile, were used in this experiment. Rabbits were individually housed in metal hutches of a commercial type (60×55×40 cm) provided with separate facilities for feeding, watering and nest box (40×30×30 cm). Rabbits were vaccinated by:

1. Cunipravac RHD (inactivated vaccine against hemorrhagic disease, HIPRA company) (0.5 ml S/C).
2. Formalized polyvalent rabbit pasteurellosis vaccine (Veterinary Serum and Vaccine Research Institute. Cairo, Egypt) (2ml S/C).
3. Ivermectin 1% against Mange (Memphis for Pharmaceuticals and Chemical Industries, Egypt) (2ml S/C).
4. Cages and nest boxes were cleaned regularly and disinfected before each kindling. Dropped urine and feces on rabbitry's floor were cleaned every day in the morning. All rabbits were reared under the same managerial conditions. All rabbits were kept under identical hygienic and environmental conditions.

### **Feeding system**

All rabbits under experiment were offered a commercial ration pellets (Super visor Company, Egypt). All nutritional requirements of rabbit does were provided according to National Research Council (NRC) (1994). The chemical analysis of the pellets was carried out according to Association of Official Analytical Chemists Official (A.O.A.C., 1990) it contained 18% crude protein, 10.19% crude fiber, 2.8% crude fat and 2635 kcal/kg diet. Rabbits were fed an amount of pellet ration that provided normal growth and maintained adult body weight. The diet and drinking water were provided twice daily at 9 a.m. and 5 p.m.

### **Climate data**

The climatic data was continuously recorded among the experimental period using thermo hygrometer the weekly averages of ambient temperature and relative humidity values at midday inside the rabbit building were estimated. The

Temperature Humidity Index (THI) was computed using the formula cited by Marai et al. (2001) for rabbits as following:

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

Where db °C = dry bulb temperature in degrees Celsius and

RH = relative humidity expressed in percentage

Obtained values of THI classified as follows: absence of heat stress (<22.2), moderate heat stress (22.2-< 23.3), severe heat stress (23.3-< 25.6) and very severe heat stress (25.6 and more) (Abd El-Moneim et al., 2013).

### Experimental design

The rabbits were randomly allocated into four equal groups (n=10) (9 does and 1 buck) as shown in table 1, and housed in separate rooms under the same environmental temperature ranged from 33-36±2 °C and relative humidity (64-79±3 %) (Balabel, 2004). All does were identified and individually mated by transferring each one to the buck cage and returned to their own hutch after copulation. Each doe was palpated 10 days post mating and if there was no pregnancy, she rebred until she got pregnant. On the 27<sup>th</sup> day of pregnancy, the nest boxes were prepared for kindling and supplied with wood sawdust to provide a warm nest for the bunnies. Kits were weaned at 28 days of age. Light/dark rate during the experimental period was 12/12 hours as suggested by Lebas et al. (1984).

**Table 1.** Description of the experimental WNZ rabbits groups used in the experiment under Egypt summer conditions, 19 June- 21 August, 2015.

Groups	Treatments
I	Kept as a control group without treatment
II	Supplemented by drinking water with Honey 20 ml/L
III	Drank cold water (temperature ranged from 16-20 °C)* by adding measurable ice cubes to water from 11 a.m.
IV	Injected subcutaneously by Levamisole (2mg/kg body weight) once**

\*Selim et al. (2004); \*\* (According to the instruction of the producer Company, Memphis for Pharmaceuticals & Chemical Industries, Egypt)

### Measured parameters

**Performance parameters:** Initial and final body weights (Kg) weights were recorded individually weekly throughout the experiment period. The feed consumption (gm/day) and water intake (ml/day) were recorded during the experimental period by weighting the amount of feed and measuring the amount of water remained, then subtracting them from the offered amount before putting the new one. Body weight gain (gm) for adult and young rabbits was calculated as difference between the initial weight and weight after 9 weeks. Feed Conversion Ratio (FCR) was calculated as the amount of food consumed for production of one unit of body gain (Marai et al., 2006). Performance index (PI) was calculated according to Yassein et al. (2008). Mortality rate for does and kits from birth till weaning was recorded.

**Reproductive parameters:** The conception rate was calculated as results of pregnancy diagnosis at first mating attempt for does that had accepted the male (Ahmed et al., 2005). Gestation period was recorded by counting the days between mating and kindling day. Amount of milk yield for each doe during the first 3 days post kindling was recorded according to Cowie (1969). Litter weight and size of total kits born and individual kit weight at kindling and weaning. Fetal losses and dead kits before weaning were recorded.

**Physiological parameters:** Blood samples were collected on a weekly basis, in the morning from the marginal auricular vein from 3 rabbits of each group, into 2 test tubes, the first tube containing EDTA for hematological analysis. Second tube was the centrifuge tube, left to clot and centrifuged to obtain clear serum for serum biochemical analysis kept in a deep freezer at -20°C until analysed (Schalm et al., 1975).

**Hematological parameters:** Whole blood samples were analyzed shortly after collection for measuring Red Blood Cell (RBC) counts, Packed Cell Volume (PCV), total and differential leukocytic count (Coles, 1986). Hemoglobin was determined by colorimetric method (Schalm et al., 1975).

### Serum biochemical analysis

Serum samples were used for measuring serum total protein, urea, creatinine and glucose by using commercial kits (Diamond Diagnostics, Egypt). Globulin was determined by subtracting albumin from total protein (Schalm et al., 1975).

### Respiration rate and rectal temperature

The respiration rate was recorded by counting the flank movements per minute by using a hand counter. The rectal temperature was measured by using a clinical thermometer inserted into the rectum for 2 minutes at depth of 2 cm (Marai et al., 1999).

### Economic efficiency

Economic Efficiency (EE) was calculated as the ratio between income (price of weight gain) and cost of feed consumption during the experimental period according to Abd-Ella et al. (1988).

### Statistical analysis

Data were tested for distribution normality and homogeneity of variance. Data was reported as mean  $\pm$  standard error of the mean and analyzed by ANOVA using SAS (Statistical Analysis Software), Institutes INC (2005). The significance of difference among the different treatments was evaluated by Tukey's test. The significance level was set at  $P < 0.05$ .

## RESULTS AND DISCUSSION

Results at Table 2 show that temperature-humidity index values estimated exceeded than 25.6, indicating exposure of the animals to sever heat stress during the hot period. The results are in the same line of earlier findings of Marai et al. (2000) and Abd El-Moneim (2001) under the same Egyptian climate conditions.

**Table 2.** Average weekly climate data during the experiment period under Egypt summer conditions, 19 June-21 August, 2015.

Weeks	Temperature ( $^{\circ}$ C)	RH (%) **	THI*
1	34.2 $\pm$ 1.1	64 $\pm$ 4	30.6
2	34.6 $\pm$ 1.5	68.1 $\pm$ 2.9	30.6
3	34.6 $\pm$ 0.97	74.8 $\pm$ 2.3	31.1
4	35.1 $\pm$ 1.77	73.4 $\pm$ 3.5	32.2
5	35.2 $\pm$ 1.49	76 $\pm$ 5.1	32.2
6	34 $\pm$ 0.81	74.2 $\pm$ 2.6	31.1
7	34.1 $\pm$ 1.06	66.3 $\pm$ 1.7	30.6
8	34.7 $\pm$ 1.38	73.1 $\pm$ 4.4	31.1
9	35.8 $\pm$ 1.21	74 $\pm$ 2.82	32.2

Mean $\pm$  standard deviation; \*THI: Temperature humidity index; \*\*RH: Relative humidity.

For judging the effect of heat stress and its alleviation that could directly or indirectly affect rabbit's performance, different live performance parameters were studied as an indicator of rabbit's welfare. The performance parameters (final body weight, body weight gain, feed intake, feed conversion ratio and water consumption) which are represented at table 3, indicated that most of growth performance traits studied on examined rabbits were inversely and significantly ( $P < 0.05$ ) affected by heat stress, as it was cleared that the control group (Group I) recorded the lower values for most of performance parameters comparing with treated groups II, III and IV. These results were in agreement with Ayyat et al. (2004) and Villalobos et al. (2008). However, addition of honey in the drinking water of the heat stressed NZW growing rabbits up to 20 mg/l water, significantly ( $P < 0.05$ ) improved most of traits concerning growth performance especially Body Weight Gain (BWG) and FCR, also this group expressed higher numerical values for final body weight, Performance Index (PI) and water consumption. The results are in coincide with Bonomi et al. (2001) who observed weight gain improvement of 11% and 15% and feed utilization improvement by 8.5% and 12.5% when royal jelly (RJ) (a honeybee secretion) was used in rabbits feeding at 15 and 20 ppm from 30 to 90 days of age, respectively. Furthermore, Han et al. (2009) also indicated a net increase in BWG and survivability in piglets with honey venom injection. Moreover, there is the finding of Bonomi (2003) who reported 11% and 14% improvement in weight gain and 5% and 7% improvement in feed utilization when pigs were fed RJ added to mixed feeds at doses of 30 and 50 ppm respectively. However, in the case of feed intake the treated group with cool water recorded the higher numerical values comparing with other treated groups and control group. These results were in agreement with Marai et al. (1999) and Abd El-Moneim et al. (2013) who reported that drinking cool water leads to increase in animal appetite and physiological functions. The findings that could be explained on the basis of that drinking cool water acts through cooling the animal body core by conduction as a result to the difference between temperatures of the drinking water and urine, mediated by cooling the area of the hypothalamus (Abd El-Moneim et al., 2013). However still honey treated group was much better in feed conversion ratio due to higher body weight gain in comparison with the amount of feed intake.

Finally, the Mortality Rate (MR) was 55% in stressed untreated group and decreased at treated groups where the honey treated group expressed lowest MR (11.2%) followed by cool water treated groups (33%) and finally the Levamisole treated group (44%). The results are in the same line of Marai et al. (2002) and Balabel (2004) who reported that rabbits are very sensitive to heat stress since they have few functional sweat glands which means they have

difficulties in eliminating excess body heat when the environmental temperature is high. Habeeb et al. (1997) reported that MR from birth up to weaning was significantly ( $P<0.05$ ) increased in response to a temperature which increased from 19.5 °C in January to 34.8 °C in July. In addition, the same authors estimated MR in adult rabbits in summer to be 18%, while no mortality was recorded during winter. Data presented at table 3, cleared that all treatment groups improved economic efficiency during the whole experimental period in comparing with control group. It was clear that, the highest value was achieved with honey treated group followed by cool water treated group and finally Levamisole treated group. These results were in accordance with those of Marai et al. (1999).

**Table 3.** Performance traits and economic efficiency % of White New Zealand rabbits under Egypt summer conditions, 19 June-21 August, 2015.

Examined items	Examined groups			
	Control group	Honey treated group	Cool water treated group	Levamisole injected group
Initial body weight (gm)	2.039±0.024	1.973±0.045	2.019±0.041	2.059±0.032
Final body weight (kg)	2.148±0.02778 <sup>a</sup>	2.546±0.05787 <sup>b</sup>	2.495±0.05643 <sup>b</sup>	2.459±0.04928 <sup>b</sup>
Body weight gain (gm)	93.25±18.84 <sup>a</sup>	576.0±23.25 <sup>d</sup>	461.0±28.18 <sup>c</sup>	328.6±31.89 <sup>b</sup>
FCR	4.269±1.096 <sup>a</sup>	1.766±0.07514 <sup>b</sup>	2.223±0.2494 <sup>ab</sup>	2.009±0.3049 <sup>b</sup>
Feed-intake (gm/day)	47.57±3.003 <sup>a</sup>	111.3±3.522 <sup>b</sup>	131.0±2.964 <sup>c</sup>	91.60±3.778 <sup>d</sup>
Water consumption (ml/day)	298.2±11.39 <sup>a</sup>	393.2±5.770 <sup>b</sup>	317.4±2.606 <sup>a</sup>	313.9±5.837 <sup>a</sup>
Performance index (%)	109.5	145.9	131.6	129.6
Mortality rate (%)	55	11.2	33	44
Economic efficiency (%)	27.6	42.4	36.7	33.5

\*Means ± Standard error which superscripts with different small letters (a-c) within the same row differ significantly at  $P<0.05$ .

Concerning to some reproductive traits of WNZ rabbits exposed to sever heat stress under the warm subtropical environmental conditions of Egypt, group (I) showed that there was a significant decrease ( $P<0.05$ ) at conception rate, gestation period, litter size at birth and weaning, litter weight at birth and weaning, and estimated milk yield comparing with treated groups. The gestation period seemed to be affected by heat stress, as the gestation period was decreased (29 days) in rabbits exposed to high ambient temperature (control group) comparing with treated ones (30 days). The number of kits was found to be lower in the control group (4 kits) than those treated by honey supplementation (8 kits), drinking cool water (7kits) and injection of Levamisole (6 kits) as shown in table 4. The results are in a harmony with those of Marai et al. (2002, 2004, 2006); Balabel (2004) and Abdel-Monem et al. (2013) who declared that an elevation of ambient temperature had a negative impact on appetite and accordingly on feed intake that ends with slowing growth and impairment of reproduction in rabbits. Moreover, these results may be attributed to the decrease in fertility and conception rate under high environmental temperature as a complex set of events were expressed in a significant reduction in total young born and in an increase in percentage of young born dead (Matassino et al., 1970). Where all the above-mentioned findings of decreased reproductive traits for untreated stressed group may emphasize the hypothesis of El-Masry et al. (1994) which approved that conception rate could be decreased under heat stress condition due to decline in live sperm concentration with a significant alteration in the levels of seminal plasma composition. Such decrease in kit's weight at birth and weaning at untreated stressed group may be attributed to, hypothermic condition of pregnant dams that leads to decrease feed intake, depressed thyroid activity and hence, metabolic rate resulting in decrease in the litter weight at birth, in addition such dams had low milk yield resulting in less feed for the growing young. Among treated groups honey treated group still represented as the much better group in most of reproductive traits conception rate (88), fetal losses (zero), dead kits before weaning (1.4±0.44), Litter weight at birth (270.3±15.33 gm.), Kits body weight at weaning (396.2±2.916 gm), Kits weight gain (576.0±23.25 gm) and milk yield (135.6±3.735 gm/day), followed by treated group by drinking cool water and finally the group injected by Levamisole. It should be noted here that honey administration possesses better feed utilization especially starch and mineral (El Nagar et al., 2010).The honey action mechanism could partially explain the increased pre-weaning weight gain, milk yield, as well as the heavier weaning weights and lower preweaning deaths.

Elevated temperature significantly affected the measured hematological parameters as shown at tables 5, which showed significant ( $P<0.05$ ) decreases in RBC, PCV, Hb, WBC and neutrophils at untreated group comparing with treated groups. On the other hand, significant ( $P<0.05$ ) increases were found in numbers of lymphocytes in the heat stressed rabbits compared to the treated groups. Basophiles were unaffected by elevated temperature. These results are in agreement with the findings of Ondruska et al. (2011), who reported that heat stress in mammals decreased the level of ACTH, which might then result in decreases in RBC counts, PCV, and Hb concentration. In addition, the depression of PCV during the hot season was also reported to be related to a reduction in cellular oxygen, a requirement for reducing

metabolic heat production in order to compensate for the elevated environmental heat load (Okab and El-Banna, 2003 and Okab et al., 2008).

**Table 4.** Reproductive traits of White New Zealand rabbits under Egypt summer conditions, 19 June- 21 August, 2015.

Examined items	Examined groups			
	Control group	Honey treated group	Cool water treated group	Levamisole injected group
Conception rate %	44	88	44	44
G. P (days)	29.67±0.2108	30.56±0.2940	30.75±0.2500	30.80±0.3742
Milk yield (gm/day)	93.33±8.999 <sup>a</sup>	135.6±3.735 <sup>b</sup>	131.8±4.765 <sup>b</sup>	100.8±6.538 <sup>a</sup>
Litter size	4.833±0.4773 <sup>a</sup>	8.222±0.3643 <sup>b</sup>	7.750±0.4532 <sup>b</sup>	6.000±0.3162 <sup>a</sup>
Fetal losses	0.3333±0.237	-	-	0.3333±0.167
Dead kits before weaning	1.556±0.5031	1.444±0.4444	1.556±0.4444	1.333±0.4714
Litter weight at birth (gm)	185.7±14.58 <sup>a</sup>	270.3±15.33 <sup>b</sup>	258.1±15.32 <sup>b</sup>	230.2±11.79 <sup>ab</sup>
Kits body weight at weaning (gm)	269.5±7.390 <sup>a</sup>	396.2±2.916 <sup>b</sup>	391.6±2.748 <sup>b</sup>	345.4±15.77 <sup>c</sup>
Kits weight gain (gm)	93.25±18.84 <sup>a</sup>	576.0±23.25 <sup>b</sup>	461.0±28.18 <sup>b</sup>	328.6±31.89 <sup>c</sup>

\*Means ± Standard error which superscripts with different small letters (a-c) within the same row differ significantly at P<0.05.

**Table 5.** Respiratory rate, rectal temperature, select hematological and biochemical parameters measured in the blood of White New Zealand rabbits under Egypt summer conditions, 19 June-21 August, 2015.

Examined items	Examined groups			
	Control group	Honey treated group	Cool water treated group	Levamisole injected group
<b>Hematological Parameters</b>				
RBCs (x10 <sup>6</sup> /μL)	4.033±0.2404 <sup>a</sup>	7.633±0.6438 <sup>b</sup>	6.267±0.2603 <sup>b</sup>	7.133±0.2333 <sup>b</sup>
Hb (g/dl)	7.933±0.2028 <sup>a</sup>	13.23±0.2728 <sup>b</sup>	10.17±0.2028 <sup>c</sup>	13.40±0.5508 <sup>b</sup>
PCV (%)	28.00±1.528 <sup>a</sup>	38.67±0.8819 <sup>b</sup>	35.33±1.856 <sup>b</sup>	40.33±0.8819 <sup>b</sup>
WBCs (μL)	3833±145.3 <sup>a</sup>	9533±409.6 <sup>b</sup>	6733±145.3 <sup>c</sup>	10567±688.8 <sup>b</sup>
Neutrophils (%)	35.33±6.741 <sup>a</sup>	53.33±1.453 <sup>b</sup>	51.67±3.283 <sup>ab</sup>	58.33±2.028 <sup>b</sup>
Lymphocytes (%)	59.67±6.960 <sup>a</sup>	40.33±0.8819 <sup>ab</sup>	41.67±4.978 <sup>ab</sup>	31.67±1.764 <sup>b</sup>
Basophils (%)	4.667±0.3333	4.333±0.3333	4.333±1.202	6.667±0.3333
<b>Serum Biochemical Analysis</b>				
Glucose (mg/dl)	47.67±3.383 <sup>a</sup>	178.0±2.517 <sup>d</sup>	93.33±3.480 <sup>b</sup>	131.0±6.083 <sup>c</sup>
Total protein (g/dl)	4.767±0.1453 <sup>a</sup>	6.567±0.2333 <sup>b</sup>	4.833±0.1453 <sup>a</sup>	5.833±0.2186 <sup>b</sup>
Albumin (g/dl)	2.567±0.2186 <sup>a</sup>	4.500±0.2082 <sup>b</sup>	2.467±0.0882 <sup>a</sup>	3.767±0.3528 <sup>b</sup>
Globulin (mg/dl)	2.200±0.3512	2.067±0.4410	2.367±0.067	2.067±0.5239
A/G ratio	1.281±0.3595	2.421±0.5816	1.042±0.0251	2.250±0.8539
Urea (mg/dl)	59.33±4.910 <sup>a</sup>	33.67±4.096 <sup>b</sup>	18.67±1.453 <sup>b</sup>	27.67±3.283 <sup>b</sup>
Creatine (mg/dl)	2.900±0.1155 <sup>a</sup>	1.367±0.3383 <sup>b</sup>	0.4000±0.058 <sup>b</sup>	1.167±0.3180 <sup>b</sup>
<b>Respiratory Rate</b>				
(breath/minute)	180.5±0.6118 <sup>d</sup>	154.5±1.156 <sup>b</sup>	150.6±0.9445 <sup>a</sup>	169.0±0.6213 <sup>c</sup>
Rectal temperature (°C)	40.00±0.02295 <sup>a</sup>	39.57±0.03500 <sup>b</sup>	39.44±0.05179 <sup>c</sup>	39.97±0.02054 <sup>a</sup>

\*Means which superscript with different small letters (a-c) within the same row differ significantly at P<0.05; RBCs: Red Blood Cells; Hb: Haemoglobin; PCV: Packed Cell Volume; WBCs: White Blood Cells; A/G ratio: Albumin Globulin ratio.

Serum biochemical analysis of the examined groups as shown at Table 5, showed significant (P<0.05) decreases of serum blood glucose (mg/dl), total protein (g/dl), albumin (g/dl), globulin (mg/dl) and albumin globulin ratio at untreated stressed group in comparing with treated groups. On other hand there was a significant (P<0.05) increase of serum urea (mg/dl) and creatine (mg/dl) level among the untreated group comparing with treated groups. The results are in a harmony of those given by Habeeb et al. (1993) and Marai et al. (1999) who reported that albumin was significantly lower when the animals were exposed to heat stress conditions. Also Habeeb et al. (1997) showed that blood glucose was decreased significantly in NZW rabbits exposed to heat stress conditions by 20.7%. The decrease in plasma glucose could also be due to the marked dilution of blood and body fluids as a whole. As well as, the increase in glucose utilization to produce more energy for greater muscular expenditure required for high respiratory activity (Habeeb et al., 1993). Moreover Okab et al. (2008) declared that decrease in glucose levels in the heat stressed adult rabbits could be due to increases in glucose utilization during muscular movements required for high respiratory activity or due to increases in corticosteroid concentrations (Habeeb et al., 1997). On the same context honey treated group showed the same trend of significant P<0.05 increase in the level of serum glucose, total protein, albumin, globulin and A/G ratio. The results are in agreement of Elnagar et al. (2010). Also, similar to the findings of Kurkure et al. (2000) who reported

increased serum albumin when white Leghorn cockerels were orally given 10 ml/bird/day RJ. On other hand the group treated with cool drinking water showed the much better records for decreased level of serum urea and creatine level. This indicates an improved kidney function in cleansing blood especially with the elevated blood proteins observed in this study (Elnagar et al., 2010).

Data presented in table 5, show significant differences ( $P < 0.05$ ) in rectal temperature ( $^{\circ}\text{C}$ ) and respiration rate in the examined groups where it recorded higher records at untreated stressed group comparing with treated groups. The results are in coincide with Marai et al. (2001) and Marai et al. (2007) who reported the highly significant increase in thermoregulatory parameters (respiration and temperatures of ear, rectum and skin) due to exposure of the animals to severe heat stress .It is well known that, adult rabbits are homoeothermic and are provided with physiological mechanisms by which they can maintain their deep body temperature constant within the thermo neutral zone. The increase in rectal temperature of the heat stressed rabbits may be due to failure of the physiological mechanism (Marai et al., 2001).The increase in respiration frequency and evaporative water loss is linearly related to the increase in ambient temperature above the panting threshold (Richards, 1976). Thus enables the animals to dissipate heat by vaporizing high moisture through the respiratory air, which accounts to about 30% of total heat dissipation. Respiration becomes the main pathway for loss of the latent heat, since most sweat glands in rabbits are not functional and perspiration is not great. Among the treated groups, cool water drinking group was much better group in improving rectal temperature and respiratory rate followed by honey treated group. The results are in coincide with Marai et al. (1999) who reported that drinking cool water acts through cooling the animal's body core by conduction as a result to the difference between temperatures of the drinking water and urine, mediated by cooling the area of the hypothalamus. Together with the high specific heat of water as well as, body water retention with drinking water that help to alleviate the rise in body temperature which are reflected in reduction of rectal temperature and respiration rate.

## CONCLUSION

From these results, it could be concluded that the adverse impact of exposure of growing rabbits to severe heat stress under the warm subtropical environmental conditions of Egypt could be mitigated through addition of honey to drinking water also via drinking cool water. This could minimize reproductive losses, as they have positive effect on rabbit's reproductive traits via increase conception rate, litter weight at birth, kits body weight at weaning and weight gain and milk yield. On other hand, decrease fetal losses .Furthermore, improve most of rabbit's performance traits.

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## Competing interests

The authors have no competing interests to declare.

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