UNIVERSITI PUTRA MALAYSIA

ENVIRONMENTAL MANIPULATIONS TO MINIMIZE THERMAL STRESS IN LAYING HENS IN A HOT HUMID CLIMATE

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By

IZZELDIN BABIKER ISMAIL

Thesis Submitted in Fulfilment of the Requirement for the Degree of Doctor of Philosophy in the Faculty of Veterinary Medicine
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DEDICATION

TO MY PARENTS, BROTHERS, SISTERS, MY WIFE HANAN, MY DAUGHTERS THOEIBA, NOESIBA, NAHLA AND MY SON MOHAMED FOR THEIR MORAL SUPPORT AND ENCOURAGMENT

Abstract of thesis presented to the Senate of Universiti Putra Malaysia
in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman: Associate Prof. Dr. Kassim Hamid

Faculty: Veterinary Medicine

Three experiments were carried out on laying hens (Hisex Brown) to investigate their performances and to determine the adverse effects of high environmental temperature. The hens were housed in light controlled rooms. Temperature treatment experiment (hot and cold), Light treatments experiment (light and dark) and acclimatization to acute heat (38.5) experiment. Rectal temperature, respiration rate, feed intake, egg production, eggshell quality, blood gas and plasma analysis were reported. The effects of high ambient temperature (35°C) and humidity (68.6%) on the physiology and production performance of laying hens showed a significant ($p<0.01$) increase in rectal temperature, respiratory rate, blood pH and efficiency of feed conversion. However the partial pressure of carbon dioxide (pCO_2), blood bicarbonate (HCO_3^-) concentration, feed intake, egg production, egg weight, eggshell thickness and albumen quality were significantly decreased

($p<0.05$). Similarly the blood packed cell volume, haemoglobin, sodium, potassium, calcium and phosphorous concentrations were also significantly decreased ($p<0.05$).

Synchronization of the dark period with the hot period of the day (Ta; 35°C, RH; 68.6%) to minimize heat stress in laying hens showed significant increases in feed intake and egg production ($p<0.01$), eggshell thickness ($p<0.05$), pCO_2 ($p<0.01$) and blood HCO_3^- concentration ($p<0.05$). However, significant decreases in the efficiency of feed conversion ($p<0.05$), egg weight ($p<0.01$) and rectal temperature ($p<0.05$) were recorded. The blood pH, plasma calcium and phosphorous concentrations of the dark-treated and the light-treated groups were not significantly different. However, plasma cholesterol concentration of the light-treated group was significantly higher ($p<0.01$) than the dark-treated group when exposed to high ambient temperature. The heart was significantly ($p<0.05$) heavier and enlarged in the birds kept in the light during the high environmental temperature of 35°C.

Acclimatization studies on the dark-treated and light-treated laying hens to acute heat of 38.5°C increases the rectal temperature to 43.9°C and 44.1°C respectively on the first day of acute heat exposure. On the following days the rectal temperature gradually decreased reaching the lowest value on day three for the dark-treated and day four for the light-treated group. Similarly, a significant increase in shank and comb temperatures were observed reflecting the body heat load, stimulating vasodilatation in an attempt to cool the body by heat dissipation. The blood pH of the dark-treated and the control groups increased to 7.59 and 7.58, respectively. The pCO_2 and HCO_3^- concentrations were significantly ($P<0.01$) increased in the dark-treated group. Plasma cholesterol concentration was significantly ($p<0.01$) increased during light and decreased during dark treatments. High temperatures during light or darkness did not affect plasma calcium or phosphorous concentration. The result concluded that the efficiency of feed conversion was improved under heat stress. However, egg production and feed intake were decreased. Dark treatment improved acclimatization to acute heat. Exposure to heat during the light increased plasma cholesterol and heart weight.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

MANIPULASI PERSEKITARAN UNTUK MEMINIMUMKAN TEKANAN TERMAL TERHADAP AYAM PENELUR DALAM IKLIM PANAS

Oleh

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Tiga kajian telah dijalankan terhadap ayam penelur (Hisex Brown) untuk menyelidik prestasinya dan untuk menentukan kesan buruk suhu persekitaran tinggi. Kesan suhu ambien tinggi (35^{o}C) dan kelembapan (68.6%) terhadap fisiologi dan prestasi penghasilan ayam penelur menunjukkan peningkatan bererti ($p<0.01$) bagi suhu rektum, kadar penafasan, pH darah dan kecekapan penukaran makanan. Walau bagaimanapun tekanan separa karbon dioksida (pCO_2), kepekatan bikarbonat (HCO_3^-) darah, pengambilan makanan, penghasilan telur, berat telur, ketebalan cangkerang telur dan mutu albumen menurun secara bererti ($p<0.05$). Begitu juga dengan isipadu sel padat darah, kepekatan hemoglobin, natrium, kalium, kalsium dan fosforus, turut turun secara bererti ($p<0.05$).

Penyelarasan tempoh gelap dengan suhu panas (Ta; 35°C, RH; 68.6%) pada sesuatu hari untuk meminimumkan tekanan haba dalam ayam penelur menunjukkan peningkat bererti dalam pengambilan makanan dan penghasilan telur ($p<0.01$), ketebalan cengkerang telur ($P<0.05$), pCO_2 ($p<0.01$) dan kepekatan HCO_3^- darah ($p<0.05$). Walau bagaimanapun, penurunan bererti dalam kecekapan penukaran makanan ($p<0.05$), berat telur ($p<0.01$), dan suhu rektum ($p<0.05$) telah direkodkan. Bagi pH darah, kepekatan kalsium dan fosforus plasma dalam kumpulan rawatan gelap dan rawatan cahaya tidak berbeza secara bererti. Walau bagaimanapun, kepekatan kolesterol plasma dalam kumpulan rawatan cahaya adalah lebih tinggi dan bererti ($p<0.01$) daripada kumpulan rawatan cahaya apabila didedahkan kepada suhu ambien tinggi. Berat jantung adalah tererti ($p<0.05$) tingginya dan membesar dalam kumpulan ayam rawatan cahaya semasa berada pada suhu persekitaran tinggi, 35°C.

Penyesuaianiklim ayam rawatan gelap dan rawatan cahaya kepada haba 38.5°C menunjukkan peningkatkan suhu rektum masing-masing kepada 43.9°C dan 44.1°C pada hari pertama pendedahan haba yang meruncing. Pada hari-hari berikutan, suhu rektum beransur turun mencapai nilai terendah pada hari ketiga untuk kumpulan rawatan gelap dan hari keempat untuk kumpulan perlakuan cahaya. Apa yang juga dicerapkan ialah peningkatan bererti bagi suhu betis dan balung yang mencerminkan beban haba badan, dan ini merangsang pemvasodilatan dalam usahan menyejukkan badan dengan menghilangkan haba. Bagi pH darah kumpulan rawatan gelap dan kawalan, masing-masing meningkat kepada 7.59 dan 7.58. pCO_2 dan kepekatan HCO_3^- meningkat ($p<0.01$) dengan bererti dalam kumpulan rawatan gelap. Kepekatan kolesterol plasma meningkat ($p<0.01$) dengan bererti dalam tempoh rawatan cahaya dan menurun dalam tempoh rawatan gelap. Suhu tinggi dibawah cahaya dan dalam kegelapan tidak memberi sebarang kesan terhadap kepekatan kalsium atau fosforus. Hasil kajian menunjukkan walaupun suhu ambien tinggi membesi kesan buruk terhadap suhu badan dan penghasilan telur, ia dapat meningkatkan kecekapan penukaran makanan masih meningkat. Kegelapan pada masa tekanan haba meminimumkan kesan buruk walaupun berat telur menurun. Rawatan gelap meningkatkan penyesuaiikliman terhadap haba yang meruncing, walau bagaimanapun cahaya dan suhu ambien tinggi secara gabungan meningkatkan kepekatan kolesterol plasma dan berat jantung.

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy.

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AH	Albumen Height
ALF	*Ad libitum* Feeding
ATPase	*Adenosine Triphosphatase*
ACTH	Adrenocorticotropin
BL	Blue Light
BMLP	Biomittent Lighting Program
BW	Body weight
^{o}C	Degree Celcius
C	Rate of convective heat transfer
CaBP	Calcium Binding Protein
CBF	Capillary Blood Flow
CE	Cholesterol Esterase
CO_2	Carbon Dioxide
ChOD	Cholesterol Oxidase
CHOL	Cholesterol
CL	Continuous light
cm	Centimeter
CS	Corticosterone
CSF	Cerebrospinal Fluid
Cp	Specific Heat Of The Body Mass
D	Dark
dt	Change in Time
DTb	Change in Body temperature
EHL	Evaporative Heat Loss
g	Gram
GL	Green Light
GLU	Glucose
HCO_3	Bicarbonate
HDL	High-density lipoprotein
H/L	Heterophil/lymphocyte ratio
h	hour time
IL	Intermittent Light
K	Rate of Conductive Heat Transfer
KCL	Potassium Chloride
L	Light
l	Liter
MHP	Rate of Metabolisable Heat Production
min	Minute
mm	Millimeter
mmol	Millimole
m/s	meter per second
NaCl	Sodium Chloride

$NaHCO_3$	Sodium Bicarbonate
PCV	Packed Cell Volume
PTU	Propylthiouracil
pO_2	Partial Pressure of Oxygen
pCO_2	Partial Pressure of Carbon Dioxide
pH	Hydrogen Ions Concentration
R	Rate of radiant heat transfer
RH	Relative Humidity
RL	Red Light
RR	Respiratory Rate
SHL	Sensible Heat Loss
T	Time
T_3	Triiodothyronine
T_4	Thyroxine
T_a	Ambient Temperature
T_b	Body Temperature
THb	Total Haemoglobin
TNZ	Thermoneutral Zone
TP	Total protein
TRI	Triglycerides
TU	Thiouracil
Tr	Rectal Temperature
ZLTE	Zone of Least Thermoregulatory Effort
ZMM	Zone of Minimum Metabolism
THb	Total Haemoglobin
Tcom	Comb Temperature
T_{cu}	Upper Critical Temperature
Tsh	Shank Temperature
WL	White Light
VE	Ventilation