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高溫環境下，飼料中添加pantethine對肉雞脂質代謝之影響

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摘要：本試驗旨在探討高溫環境下，飼料中添加 pantethine 對肉雞生長、肝臟脂質合成及血漿中相關激素濃度之影響。三組試驗肉雞自一日齡起每組飼養於個別之試驗籠中，分別飼予含 pantethine 0、100 及 200 ppm 之三種試驗飼糧，環境溫度於育雛期（1～14天）維持於 37°C，以後維持於 31 ± 3°C 至試驗結束，試驗期 8 週。

飼料中添加 pantethine 顯示改善肉雞之增重及骨骼肌（包括胸肌與腿肌）之重量，但不影響肝臟與腹腔內脂肪重量（克/100克體重）。肝臟及血漿中總膽固醇之含量，pantethine 添加組均顯著地比對照組低。血漿中高密度脂蛋白中之膽固醇（HDL－Cholesterol）濃度，pantethine 200ppm 添加組呈顯著地升高。添加 pantethine 於飼料中時，明顯地提高血漿中三酸甘油脂及游離型脂肪酸之濃度，但不影響血糖之濃度。血漿中甲狀腺素之濃度與 atherogenic index 值，則隨著 pantethine 添加量之增加而降低，pantethine 之添加量達 200 ppm 時二者明顯下降。反之，雌二醇（17β－estradiol, E_2）濃度則隨著 pantethine 添加量之增加而呈上升之傾向。pantethine 之添加明顯地提高肝臟中 Citrate cleavage enzyme（EC 4、1、3、8；CCE）、Acetyl－Co A carboxylase（EC 6、2、1、3；ACC）之活性。Nicotinamide adenine dinucleotide phosphatemalate dehydrogenase（EC 1、1、1、40；NADP－MDH）之活性於 pantethine 200 ppm 添加組呈顯著的高值，而 Fatty acid synthetase（FAS）之活性則不受 pantethine 添加之影響。pantethine 添加組之 Hydroxylmethyl－glutaryl－Co A reductase（EC 1、1、1、34；HMG－Co A reductase）活性呈較低之傾向。

一、前　言

動物飼養於高溫環境下，導致增加飲水量與減低飼料採食量[27]，增重減低[20]，血漿中甲狀腺素（Thyroxine，T_4）下降[12,23]。生長期雞隻血漿中之雌二醇（17B-estradiol，E_2），助孕素（Progesterone，P_4）及鈣之濃度均降低[17]，並降低肝臟中脂質之含量[7,8,9]，而產卵雞則呈相反現象，血漿中 E_2 與 P_4 之濃度隨著環境溫度之上升而升高[14]，增加肝臟中脂質之蓄積[6]，而易形成脂肪肝。Braganza etal, (1973)[13]指稱肉雞飼養於高溫環境下，血漿中之游離型脂肪酸（non-esterified fatty acid, NEFA）顯著降低。由此可知高溫常造成雞隻之生理改變，易導致生理之異常，且在不同生理條件下之雞隻，對高溫之反應亦異。

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維生素、氨基酸及油脂常被研究添加於飼料中，以期緩和熱緊迫，並促進雞隻之增重，改善飼料效率[10,26,33]。例如飼料中添加維生素 C，可改善雞隻對熱緊迫之抗力、降低死亡率[5,22,28,29]，並可改善雌肉雞之增重量[26]。

pantethine [D-bis (N-pantothenyl-B-amino ethyl) disulfide] 是類似維生素之物質，在生物體內被轉變成 pantethine 生成輔酶 A (CoA)，參與生物體內各種物質代謝。其與脂質代謝之關係(如圖 1 所示)，爲可促進脂肪酸之 β-氧化，合成 acyl carrier protein 及經三羧酸 (TCA) 回路之 acetyl-CoA 參與脂肪酸和膽固醇之合成。Thompson et al,(1954)[37]最先報告指出肉雞飼料中添加 pantethine，可促進肉雞之生長，提高增重量。許氏等 (1987)[18]報告顯示在舒適溫度下，產卵雞飼予能引起肝臟脂質合成亢進，血中膽固醇與 E_2 濃度升高之玉米大豆粉飼料時，若飼料中添加 pantethine，則可有效降低肝臟中脂質合成及血中膽固醇與 E_2 之濃度；但在同條件下，產卵雞經飼予大麥大豆粉飼料時，肝臟中脂質合成及血中膽固醇與 E_2 之濃度均低，此時飼料中雖添加 pantethine，則無顯著影響。在舒適溫度下 pantethine 飼予雌肉雞，其影響肝臟脂質合成及血中 E_2 濃度之效果亦不顯著[3]。此乃顯示在不同的生理狀況下，pantethine 具有不同之效果，可能 pantethine 具有調節生理正常之作用。

本試驗之目的乃在研究肉雞飼養於高溫環境，由熱緊迫致使生長遲緩之生理狀況下，於飼料中添加 pantethine 對肉雞生長及肝臟脂質合成與血中雌二醇，甲狀腺素濃度之影響。

二、材料與方法

(一)、試驗動物與管理

選取活力良好一日齡之雌肉用雛雞(日本後藤孵卵場產)，逢機分成 3 個處理組，每組 6 隻，分別飼養於試驗籠中，至 4 週齡止 3 個處理組之雞隻分別飼予(1)市售肉雞生長期配合飼料 (CP = 22%，ME=3200 Kcal) 爲基本飼料，做爲對照組。(2)基本飼料添加 pantethine (日本第一製藥出品，商品名爲 pantocin，每克含1/5克之 pantethine) 100ppm。(3)基本飼料添加 pantethine 200ppm 等三種試驗飼料。4-8 週齡時將基本飼料更換爲肉雞肥育期飼料 (CP = 19%, ME = 3000 Kcal)，而 pantethine 之處理與生長期之處理相同。試驗期中飼料與水採自由攝食。每週測定各處理組之飼料採食量，並統計至 8 週齡之飼料總採食量。試驗雞舍內之溫度，除 1～14 日齡於育雛器內 37°C 育雛外，14 日齡以後維持於 31±3°C 之環境下飼養。

(二)、採樣步驟

於 8 週齡試驗結束時，試驗雞隻分別秤重後，以 heparin 處理過之注射筒由靜脈分別抽取約 10ml 之血液後，斷頭屠殺之，隨後立即分別摘出肝臟及腹腔內脂肪，並剝離胸肌與腿肌，分別秤量其重量。

採取之血液樣品分別經遠心分離採取血漿，然後於 -30°C 貯存供分析血漿中三酸甘油脂 (triglyceride)，總膽固醇(total cholesterol)，燐脂質 (phospholipid)，游離型脂肪酸 (non-esterified fatty acid)，高密度脂蛋白中之膽固醇(HDL-cholesterol)，雌二醇 (E_2)、甲狀腺素 (T_4) 及葡萄糖之濃度。

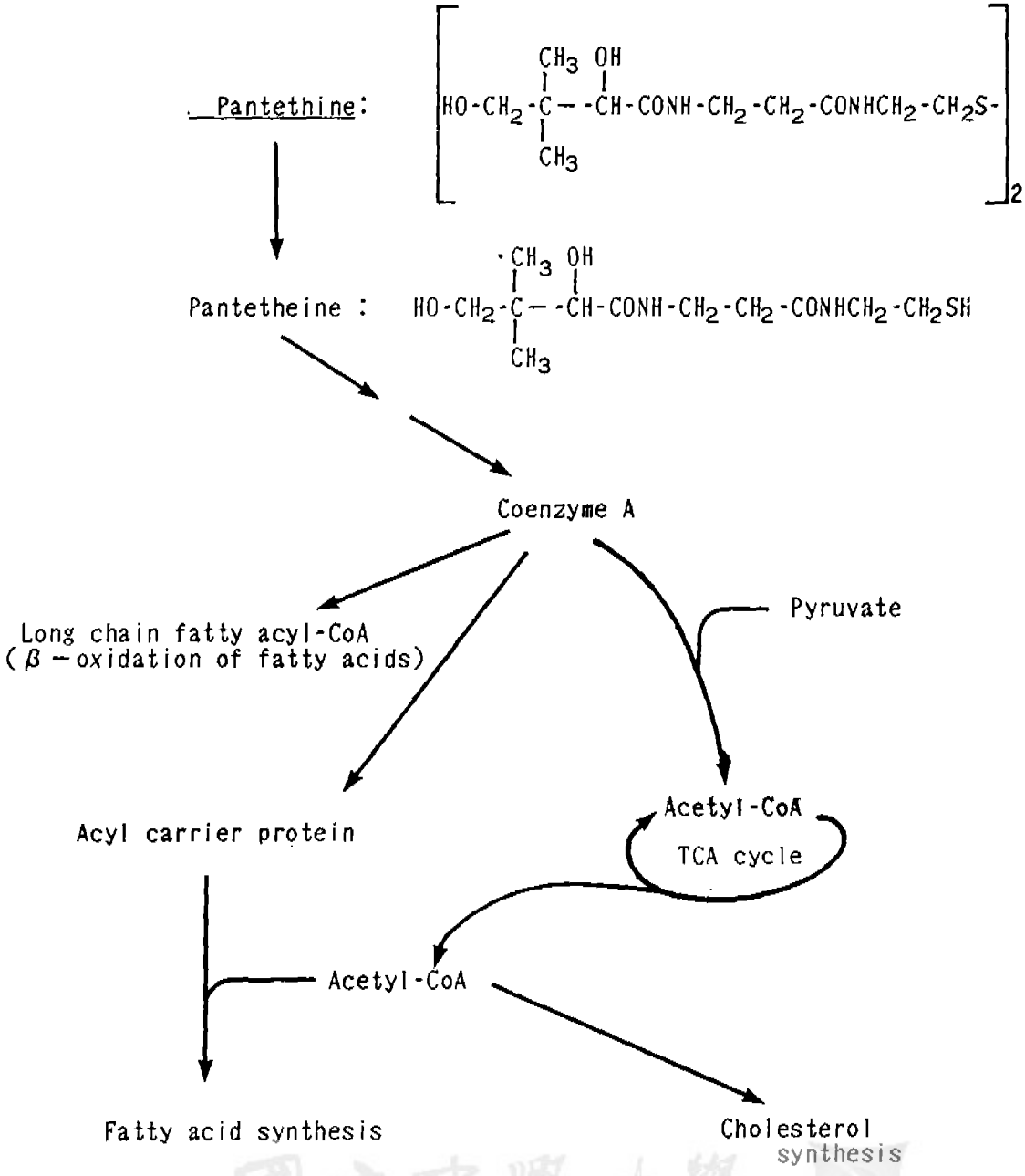

圖 1. Pantethine 之化學構造與其參與之脂質代謝

Fig. 1. The chemical structure of pantethine and its participation in lipid metabolism.

採取之肝臟樣品，一部分立即於當日測定脂肪酸合成關連酵素，包括Citrate cleavage enzyme(EC4、1、3、8；CCE)，Acetyl-CoA carboxylase(EC6、2、1、3；ACC)，Nicotinamide adenine dinucleotide phosphate-malate dehydrogenase(EC1、1、1、40；NADP-MDH)，Fatty acid synthetase (FAS)之活性及胆固醇合成關連酵素β-Hydroxylmethyl-β-glutaryl-CoA reductase(EC1、1、1、34；HMG-CoA reductase)之活性。剩餘部分於-30°C下貯存，供分析三酸甘油脂，總胆固醇及燐脂質之含量。

㈢、分析方法

1. 血漿及肝臟中各種脂質成分之測定

血漿及肝臟中三酸甘油脂，總胆固醇及燐脂質之含量，依照 Tanaka et al(1979)[35]報告之方法測定。依照久城等人(1970)[1]報告之 Itaya-Ui 改良法測定血漿中游離型脂肪酸之濃度。應用 heparin-Mn結合沈澱法測定用 Kit，HDL-cholesterol-Test wako (和光純藥工業株式會社製)之方法，測定血漿中高密度脂蛋白中之胆固醇之濃度。

2. 肝臟中脂肪合成關連酵素活性測定

⑴酵素液之調整

採用 Utter 與 Keech (1963)[38]之方法調整供測定酵素活性用之酵素液。切取4克已預先冷却之肝臟放於1 mM EDTA-2 Na、0.25 M Sucrose 8 ml之溶液中，先以剪刀細切後，使用均質機(ULTRA-DISPERSER MODEL LK-21-YAMATO 科學株式會社製)在一面冷却一面均質之情況下，均質一分鐘。均質液於4°C，9,800 r、p、m(10,000xg)遠心分離10分鐘，使細胞核與粒線體沈澱；取上清液再經於4°C，40,000 r、p、m(105,000xg)遠心分離60分鐘，使 Microsome 沈澱，上清液爲細胞質液供測定脂肪酸合成關連酵素，CCE、ACC、NADP-MDH及FAS活性之用。沈澱物(Microsome)以測定HMG-CoA reductase活性用之緩衝液充分洗淨後，再以與上層細胞質液等量之緩衝液稀釋後，供測定 HMG-CoA reducetase 之活性。

⑵酵素活性之測定方法

CCE 依 Takeda et al (1963)[34]，NADP-MDH 依 Ochoa (1955)[25]之方法測定之，以同位素 ^{14}C 結合追踪免疫法測定 FAS[19]及 ACC[30]與 HMG-CoA reductase[30]等酵素之活性。

⑶酵素液中蛋白質含量之測定

爲計算單位蛋白質之酵素活性，依照 Lowry et al (1951)[21]之方法測定酵素液中蛋白質之含量。

⑷血液中雌二醇與甲狀腺素之測定

採用 Nakamura et al (1974)[24]所述之放射性免疫分析法(Radioimmunoassay, RIA)測定法測定血漿中雌二醇(E_2)之濃度。而甲狀腺素(T_4)濃度之測定則以酵素免疫分析法[EIA-test T_4 (BMY)]測定之。

⑸血漿中葡萄糖濃度之測定

採用 Bergmeyer 與 Bernt (1974)[11]所述之 glucose oxidase 法測定血漿中葡萄糖之濃度。

⑹血漿中 atherogenic index 之計算

Atherogenic index=(總胆固醇量-高密度脂蛋白中之胆固醇量/高密度脂蛋白中之胆固醇量)×100

四、統計分析法

各項目分析所得之結果採用 Student

氏之 t 檢定，測定 pantethine添加組與對照組間之差異顯著性。

三、結　果

㈠、雞隻之飼養成績

pantethine對各處理組雞隻增重，飼料採食量，飼料效率及肝臟與腹腔內脂肪重量（克/100克體重）之影響列示於表1。就增體重而言 pantethine 200ppm 添加組與對照組比較呈顯著高值，每隻雞較對照組高176克，pantethine 100ppm 添加組統計上雖無顯著提高，但仍有較高之傾向、平均每隻較對照組重49克。平均每隻日採食量 pantethine添加組均較高。肝臟與腹腔內脂肪重量，pantethine之處理並無顯著之變化。

表一、飼料中添加 pantethine對肉雞增重，飼料採食量，飼料效率及肝臟與腹腔內脂肪重量之影響

Table 1. Effects of dietary pantethine supplementation on body weight gain, feed consumption, feed conversion, liver and abdominal fat weights of broilers.

Measurement	Control[1)]	P-100[2)]	P-200[3)]
Body weight gain, g/bird	1852±20[4)]	1901±25	2028±24*
Daily feed comsumption, g/bird	70.11	70.61	74.24
Feed conversion	2.12	2.08	2.05
Liver weight, g/100g body weight	2.1±0.1	2.0±0.1	2.1±0.1
abdominal weight, g/100g body weight	3.9±0.4	4.0±0.3	3.9±0.1

1. Diet unsupplemented with pantethine.
2. Diet supplemented with pantethine 100ppm.
3. Diet supplemented with pantethine 200ppm.
4. Mean ± S.E for six birds.

* Significantly different ($P<0.05$) from the diets unsupplemented with pantethine.

pantethine對各處理組雞隻之骨骼肌（胸肌＋腿肌）重量之影響如表2所示。每隻雞骨骼肌之重量與增重量呈相同趨勢，pantethine 200ppm添加組在統計上呈顯著的增加，平均每隻雞較對照組重35.8克，pantethine 100ppm添加組亦有較高之趨

勢，但就對單位體重而言，則各處理組間並無大差異。

表二、飼料中添加 pantethine 對肉雞骨骼肌[1] 重量之影響

Table 2. Effect of dietary pantethine supplementation on skeleton muscle[1] weight of broilers.

Measurement	Skeleton muscle weight	
	g/bird	g/100g body weight
Control[2]	417.0 ± 9.4[5]	24.4 ± 0.6
P-100[3]	435.1 ± 9.0	23.6 ± 0.6
P-200[4]	452.8 ± 12.8*	24.9 ± 0.7

1). Skeleton muscle includes breast and thighs muscle.
2). Diet unsupplemented with pantethine.
3). Diet supplemented with pantethine 100ppm.
4). Diet supplemented with pantethine 200ppm.
5). Mean ± S.E. for six birds.
* Significantly different ($P<0.05$) from the diet unsupplemented with pantethine.

㈡、肝臟及血漿中各種脂質成分

表 3 列舉 pantethine 添加於飼料中對肉雞肝臟及血漿中各種脂質成分之影響。肝臟中三酸甘油脂之含量，pantethine 添加組與對照組比較均無顯著之差異，但有較高之趨勢。總胆固醇含量則 pantethine 添加組均呈顯著地降低，而燐脂質含量各處理組間無大差異。另方面肉雞飼料中添加 pantethine 100 或 200ppm 時，血漿中之三酸甘油脂濃度呈提高或提高之傾向。血漿中總胆固醇濃度則因 pantethine 之添加而呈極顯著地降低。反之，高密度脂蛋白中之胆固醇之濃度，pantethine 200ppm 添加組呈極顯著地提高，pantethine 100 ppm 添加組雖未達顯著地提高，但有增加之傾向。燐脂質之濃度，pantethine 添加組呈較高之趨勢，但統計上未達顯著水準。而游離型脂肪酸之濃度，則 pantethine 添加組呈顯著地降低。

㈢、血漿中葡萄糖、甲狀腺素、雌二醇濃度及 Atherogenic index 值。

肉雞飼料中添加 pantethine 對血漿中葡萄糖、甲狀腺素、雌二醇濃度及 Atherogenic index 值之影響列如表 4 所示。飼料中添加 pantethine 對肉雞血漿中葡萄糖濃度並無顯著之影響。而甲狀腺素之濃

表三、飼料中添加 pantethine 對肉雞肝臟及血漿中各種脂質成分之量之影響

Table 3. Effects of dietary pantethine supplementation on various lipid fractions in the liver and the plasma of broilers.

Measurement	Control[1)]	P-100[2)]	P-200[3)]
Liver			
Triglyceride , mg/g	44.7 ± 7.1[4)]	54.2 ± 4.0	56.5 ± 4.9
Total cholesterol , mg/g	3.7 ± 0.1	3.2 ± 0.1**	3.2 ± 0.1**
Phospholipid , mg/g	32.8 ± 1.2	33.5 ± 0.8	31.4 ± 0.6
Serum			
Triglyceride , mg/dℓ	83.6 ± 8.0	120.4 ± 14.3*	93.3 ± 8.7
Total cholesterol , mg/dℓ	116.3 ± 2.4	103.2 ± 3.4**	102.4 ± 4.7**
HDL- cholesterol , mg/dℓ	60.4 ± 2.7	69.1 ± 4.6	71.6 ± 2.1**
Phospholipid , mg/dℓ	210.1 ± 7.2	247.2 ± 16.8	230.7 ± 7.3
Non-esterified fatty acid , μeq/ℓ	133.8 ± 4.0	155.6 ± 8.8*	156.6 ± 10.1*

1. Diet unsupplemented with pantethine.
2. Diet supplemented with pantethine 100ppm.
3. Diet supplemented with pantethine 200ppm.
4. Mean ± S.E. for six birds.
   *,** Significantly different ($P<0.05$, $P<0.01$) from the diet unsupplemented with pantethine.

表四、飼料中添加 pantethine 對肉雞血漿中葡萄糖，甲狀腺荷爾蒙(T_4)，雌二醇(E_2)之濃度及 Atherogenic index 之影響

Table 4. Effects of dietary pantethine supplementation on the concentrations of glucose, thyroxine (T_4) and estradiol (E_2), and on the Atherogenic index in the plasma of broilers.

Measurement	Control[1)]	P-100[2)]	P-200[3)]
Glucose, mg/ dℓ	230.7 ± 8.7[4)]	252.8 ± 10.3	241.0 ± 5.5
Thyroxine, ug/ dℓ	2.8 ± 0.3	2.1 ± 0.4	1.9 ± 0.1*
Estradiol, pg/ dℓ	213.7 ± 19.3	222.0 ± 33.6	248.8 ± 19.7
Atherogenic index	82.4 ± 8.9	73.2 ± 9.9	59.0 ± 5.1**

1. Diet unsupplemented with pantethine.
2. Diet supplemented with pantethine 100ppm.
3. Diet supplemented with pantethine 200ppm.
4. Mean ± S.E. for six birds.
*,** Significantly different ($P<0.05$, $P<0.01$) from the diet unsupplemented with pantethine.

度，因 pantethine 之添加呈下降之趨勢，pantethine 200ppm 添加組呈顯著地降低。反之雌二醇之濃度則隨著 pantethine 添加量之增加而呈上升之傾向，不過添加量達 200ppm 尚未達顯著差異。由人類常做爲臨床醫學上判斷動脈血管硬化程度指標之 Atherogenic index 值觀之，肉雞飼料中添加 pantethine 有降低其血漿中 Atherogenic index 值之現象，pantethine 200ppm 添加組呈極顯著地降低。

㈣、肝臟中脂肪酸及胆固醇合成關連酵素之活性

表 5 顯示飼料中添加 pantethine 對肝臟中脂肪酸及胆固醇合成關連酵素活性之影響。

飼料中添加 pantethine 時，顯著地提高肝臟中 CCE 及 ACC 之活性。NADP－MDH 之活性亦於飼料中添加 200 ppm 之 pantethine 時呈顯著地提高。FAS之活性則 pantethine 之添加無顯著地影響，但呈

表五、飼料中添加 pantethine 對肉雞肝臟中脂質與胆固醇合成關連酵素活性之影響

Table 5. Effects of dietary pantethine supplementation on the activities of hepatic lipogenic and cholesterogenic related enzymes of broilers.

Measurement	Control[1)]	P-100[2)]	P-200[3)]
CCE[5)]	40.7 ± 2.3[4)]	52.1 ± 4.5*	51.2 ± 2.7*
NADP-MDH[5)]	78.6 ± 10.5	89.1 ± 5.7	102.2 ± 2.8*
ACC[6)]	1.5 ± 0.1	2.2 ± 0.1**	1.9 ± 0.1**
FAS[6)]	2.7 ± 0.3	3.1 ± 0.2	3.1 ± 0.2
HMG-CoA reductase[7)]	249.3 ± 44.3	171.1 ± 24.2	203.1 ± 26.0

1. Diet unsupplemented with pantethine.
2. Diet supplemented with pantethine 100ppm.
3. Diet supplemented with pantethine 200ppm.
4. Mean ± S.E. for six birds.
5. Activities expressed as nanomoles substrate converted to product per minute per mg protein at 25°C.
6. Activities expressed as nanomoles substrate converted to product per minute per mg protein at 38°C.
7. Activities expressed as pico moles substrate converted to product per minute per mg protein at 37°C.

CCE, citrate cleavage enzyme; NADP-MDH, NADP-malate dehydrogenase; ACC, acetyl-CoA carboxylase; FAS, fatty acid synthetase; HMG-COA reductase, β-hydroxy-β-methylglutaryl-COA reductase.

*,** Significantly different ($P<0.05$, $P<0.01$) from the diet unsupplemented with pantethine.

較高之現象。而肝臟中胆固醇合成相關酵素 HMG－CoA reductase 之活性則因 pantethine 之添加而呈下降之趨勢。

四、討　論

由本試驗顯示添加具維生素性質之 pantethine 於飼料中可改善肉雞之增重，飼料採食量及飼料效率。此與 Thompson (1954)[37]之報告指稱肉雞飼料中添加 pantethine 可提高肉雞增重量之結果一致。每隻雞骨骼肌之重量與增重量之趨勢亦一致，pantethine 之添加可提高每隻雞骨骼肌之重量，不過以每 100 克體重之骨骼肌重量則與對照組無差異。此顯示pantethine 乃促進雞隻各部位之平衡發展。而 pantethine 之能促進雞隻之生長加速及改善飼料效率者，可能是一方面由於 pantethine 本身或轉變成pantetheine與 CoA，而促進基礎代謝之亢進，雖甲狀腺素濃度降低，但其他激素濃度及酵素活性均見增高，因而增加採食量。另方面據高嶋等 (1980)[2] 之報告指稱 pantethine 具 S－S 結構，可抑制 insulin 之分解而增加 insulin 之作用，影響糖代謝及脂肪酸之合成，因而使生長及飼料效率獲得改善。也可能因具S－S結構與 GSSG (氧化型之 glutathione) 同樣具影響蛋白質開始合成之作用，可能增加 ApoA－1 之合成，促成蛋白質之合成增加[4]。

雞血漿中雌二醇濃度與脂肪酸合成之關係已有多數研究報告，增加雞隻採食量引起血漿中雌二醇之濃度提高[15]，而雌二醇濃度與脂肪酸之合成成正相關[36]，即雌二醇會促進脂肪酸合成相關酵素之活性。並會抑制脂肪酸之 β －氧化分解[16]。本試驗顯示血漿中三酸甘油脂與游離型脂肪酸含量，pantethine 添加組呈增高之現象，且肝臟中脂肪酸合成關連酵素，CCE、ACC 及 NADP－MDH 之活性及血漿中雌二醇之濃度，pantethine 添加組呈增高或增高之傾向。由此推測 pantethine之添加提高採食量及血中雌二醇之濃度，且pantethine 於生物體內轉變成 CoA再經由acetyl－CoA 及 Acyl carrier protein之徑路，造成脂肪酸合成系之亢進，增加肝臟脂質之合成並增加脂質輸送入血中。但腹腔內脂肪重量 (克 /100 克體重) 並未增加，此或許亦可說明 pantethine 具多方面之影響，在高溫環境下，除可促進肉雞脂肪之合成外，並增加蛋白質之合成，致生長加速，提高增重。由本試驗之結果顯示血漿中甲狀腺素 (T_4) 之濃度，因 pantethine 之添加而呈下降之現象，此似與pantethine 可促進生長不一致，然影響生長之因素非常複雜，非單純甲狀腺素之因素。T_4 對家禽生長之影響，可能直接作用於生長器官或在肝臟中經 Monodeiodination enzyme 之作用轉變成 T_3 再作用於生長器官。據 Scanes，et al (1984)[32] 之報告甲狀腺素 (T_4) 對雞生長之影響可能主要轉變爲 T_3，再發生作用，由本試驗之結果或許亦可說明 T_4 對雞生長之影響並非主要因素，或許 pantethine 可促進 T_4 轉變成 T_3 或可促進其他生長因子之分泌，不過在本試驗無法證明。

許氏等 (1987)[18] 曾指出pantethine添加於玉米大豆粉飼糧飼養產卵雞時，有降低血漿中總胆固醇濃度之效果。本試驗進一步證明在高溫環境下，pantethine 添加於肉雞飼料時，也具有降低血漿中總胆固醇濃度而提高 HDL－胆固醇之濃度。且

本試驗尚顯示在人類臨床醫學上，常做爲動脈血管硬化程度判斷指標之Atherogenic index 值由於 pantethine 之添加呈降低之現象。本試驗同時顯示胆固醇合成系中之主要酵素 HMG－CoA reductase 之活性，pantethine 添加組有較低之現象，此酵素爲胆固醇合成過程之中間產物 HMG-CoA 轉變成 Mevalonic acid 所需之觸酶，此酵素活性降低或可說明肝臟及血漿中總胆固醇含量降低之部分原因。

由以上之結果觀之，在高溫環境下肉雞飼料中添加 pantethine之結果，與許氏等 (1987)[18]在產卵雞飼料中添加pantethine 顯示降低產卵雞血漿中雌二醇濃度及肝臟中脂質聚積之現象相反，此可能是因產卵雞與肉雞之生理差異，產卵雞爲產卵需要，肝臟中之脂質合成較肉雞旺盛，且血中雌二醇之濃度亦較肉雞高。pantethine如前所示具多方面之作用，可能具調節生理性狀之效應，在高溫環境下可能促進肉雞肝臟脂肪合成大於分解，而在脂肪合成作用相當亢進之產卵雞則相反，可能促進脂肪分解大於合成。而 pantethine 對肉雞及產卵雞血漿中總胆固醇含量之降低，則呈一致之現象。

參 考 文 獻

1. 久城英人、高野圭以、曾山浩吉、福井　巖。1970。血清游離脂肪酸比色定量法に關する檢討(第7報)。－Itaya－Ui改良法について—— 臨床病理。18：833～837.
2. 高嶋隼二、川室厚子、後神秀基、秦　滿男、松岡　瑛。1980。パンテチンのインシュリン作用の增強について。第4回パンテチンシンポジュウム：192。東京。
3. 許振忠。1985。飼料組成および pantethine の飼料への添加がニワトリの脂質代謝におよぼす影響。岐阜大學碩士論文。
4. 富川宗博、中安敏郎、倭克　彥、安孫子雍史。1980。高 LDL 血症ウサギの HDL 代謝に及ぼす pantethine の影響。第4回パンテチンシンポジュウム：131。東京。
5. **Ahmad, M.M., R.E. Moreng, and H.D. Muller, 1967. Breed responses in body temperature to elevated environmental temperature and ascorbic acid. poultry Sci. 46: 6-15.**
6. **Akiba, Y., K. Takahashi., M. Kimura., S-1. Hirama, and T. Matsumoto, 1983. The influence of environmental temperature, thyroid status and a synthetic Oestrogen on the induction of fatty livers in chicks. Brit. poultry Sci. 24: 71-80.**
7. **Balnave, D. 1972 a. The influence of environmental temperature on liver and carcass lipid content and hepatic lipogenic enzyme activity in the immature male chick. comp. Bioch. and physiol. 43B: 109-117.**

8. Balnave, D. 1972 b. The effect of temperature and length of exposure on liver Composition and hepatic lipogenic enzyme activity in the immature male chick. Comp. Bioch. and physiol. 43B: 999-1007.
9. Balnave, D. 1973. The influence of thyroxine and environmental temperature on the specific activity of hepatic malic enzyme in young male chicks. Comp. Bioch and physiol. 44A: 1069-1074.
10. Balnave, D., R. B. Cuming, and T.M. Sutherland, 1977. A biochemical explanation for the fatty liver and kidney syndrome of broilers: its alleviation by the short - term use of dietary fat. Brit, J. Nutr. 38: 319-328.
11. Bergmeyer, H.U., and E. Bernt. 1974. Determination with glucose oxidase and peroxidase : Method with 2, 2 - azinodi (3-ethyl benzthiazoline)-6-Sulophate (ABTS), in Method of Enzymatic Analysis, 2nd ed., Vol. 3: 1205-1215(Bergmeyer, H. V. ed.), Academic press inc., New York. San Francisco, and London.
12. Bobek, J., J. Nieggoda, M. pietras, M. Kacenska, and Z. Ewy. 1980. The effect of acute cold and warm ambient temperatures on the thyroid hormone concentration in blood plasma, blood supply, and oxygen consumption in Japanese guail. Gen. Comp. Endocrinol. 40: 201-210.
13. Braganza, A.F., R.A. peterson, and R J. cenedella. 1973. The effects of heat and glucagon on the plasma glucose and free fatty acids of the domestic fowl. poultry Sci. 52: 58-63.
14. Erb, R.E., A.N. de Andrade, and J.C. Rogler. 1978. Interrelationships between diet and elevated temperatures (cyclic and constant) on concentrations of progesterone, estradiol-17β, and testosterone in blood plasma of laying hens. poultry Sci. 57: 1042-1051.
15. Haghighi-RAD, F., and D. Polin. 1981. The relationship of plasma estradiol and progesterone levels to the fatty liver hemorrhagic syndrome in laying hens. poultry Sci. 60: 2278-2283.

16. Hasegawa, S., T. Niimori, K. Sato, Y. Hikami, and T. Mizuno. 1982. Effect of estrogen on triglyceride metabolism in Chick liver. Jpn. J. Zootech. Sci. 53: 699-706.
17. Hideaki, T.J., and T.M. Huston. 1980. Effects of environmental temperature on the concentration of serum estradiol, progesterone, and Calcium in maturing female domestic fowl. poultry Sci. 59: 2797-2802.
18. HSU, J.C., K. Tanaka, S. Ohtani, and C.M. Collado, 1987. Effects of pantethine supplementation to diets with different energy cereals on hepatic lipogenesis of laying hens. Poultry Sci. 66:280-288.
19. HSU, R., Y.G. Wasson, and J.W. porter. 1965. The purification and properties of the fatty acid synthetase of pigeon liver. J. Biol. Chem. 240: 3736-3746.
20. Huston, T.M. 1965. The influence of different environmental temperatures on immature fowl. poultry Sci. 44: 1032-1036.
21. Lowry, OH., N.J. Rossbrough, A.L. Farrand, R.T. Randall. 1951. Protein measurement with folin phenol reagent, J. Biol. Chem. 193: 265-275.
22. Lyle, G.R., and R.E. Moreng. 1968. Elevated environmental temperature and duration of post exposure ascorbic acid administration. Poultry Sci. 47: 410-417.
23. May, J.D. 1974. Thyroid hormone concentration in chicken plasma. proc, and Abstr. of the XV World's Poultry Congr. and Exp. 508-509.
24. Nakamura, T., M. Shodono, and Y. Tanabe. 1974. A manual of radioimmunoassay of estradiol and progesterone in animal tissues and fluids. Res. Bull, Fac. Agric. Gifu univ. 36: 319-328.
25. Ochoa, S., 1955. Malic enzyme. In: Methods Enzymology. Vol. 1 (Colwisk, S.P., and N.O. Kaplan, eds.): 739, Academic press, New York.
26. Pardue, S.L., J.P. Thaxton, and J. Brake. 1985. Influence of

supplemental ascorbic acid on broiler performance following exposure to high environmental temperature. Poultry Sci. 64: 1334-1338.

27. Parker, J.T., M.A. Boone, and J.F. Knechtges. 1972. The effect of ambient temperature upon body temperature, feed consumption, and water consumption using two Varieties of turkeys. Poultry Sci. 51: 659-664.
28. Perek, M., and J. Kendler. 1962. Vitamin C supplementation to hen's diets in a hot Climate. Poultry Sci. 41: 677-678.
29. Perek, m., and J. Kendler. 1963. Ascorbic acid as a dietary supplement for white leghorn hens under Conditions of Climatic stress. Brit. Poultry Sci. 4: 191-200.
30. Qureshi, A.A., W.C. Burger, N. Prentice, H.B. Bird, and M. L. Sunde. 1980. Regulation of lipid metabolism in chicken liver by dietary cereals. J. Nutr. 110: 388-393.
31. Rose Brough, RW., and N.C. Steele. 1985. Effect of dietary fat and environment on lipogenosis by large white breeder turkey. Poultry Sci. 64: 1170-1176.
32. Scanes, C.G., S. Harvey, J.A. Marsh, and D.B. King. 1984. Hormones and growth in poultry. Poultry Sci. 63: 2062-2074.
33. Sinurat, A.P., and D. Balnave. 1985. Effect of dietary amino acids and metabolizable energy on the performance of broilers kept at high temperature. Brit. Poultry Sci. 26: 117-127.
34. Takeda, Y., F. Suzuki, and H. Inoue. 1963. Citrate-cleavage enzyme, In: Methods in Enzymology. Vol. 5: 154. Academic press. Inc. New York.
35. Tanaka, K., K. Kitahara, and K. Shigeno. 1979. Effect of dietary protein level on lipid metabolism in growing chicks. Jpn. J. Zootech. Sci. 50: 44-54.
36. Tanaka, K., J.C. HSu, S. Ohtani, and C.M. Collado. 1986. Changes in the activities of hepatic lipogenic - related enzymes and in the concentrations of Various plasma and liver lipid

fractions in hens before and after the onset of laying, Jpn. Poultry Sci. 23: 203-210.

37. Thompson, R.Q., O.D. bird, and F.E. peterson. 1954. The utilization of pantethine as compared to calcium pantothenated by the chick. J. Nutr. 53: 365-375.

38. Utter, M.F., and D.B. Keech. 1963. Pyruvate Carboxylase. 1. Nature of the reaction. J. Biol. chem. 238:2603. 1963.

Effects of Dietary Pantethine Supplementation on Hepatic Lipogenesis of Broilers under High Ambient Temperature

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Summary

Effects of dietary pantethine supplementation on the growth rate, hepatic lipogenesis, plasma 17β-estradiol and thyroxine concentrations in broilers were studied. Day old female broilers were divided into three groups of six birds each and housed in wire cages and fed on three different experimental diets that the basal diet supplemented with pantethine at 0, 100 or 200ppm, respectively, and lasted for eight weeks. The laboratory temperature was maintained at 37°C for the first two weeks, then reduced to 31°C ± 3°C when the experimental period.

The weight gain, skeleton muscle content of the group fed with the diet supplemented 200ppm of pantethine were improved, however, the liver and abdominal weights (g/100g body weight) were not significantly affected. On the other hand, the liver and plasma total cholesterol contents were significantly lower in the birds fed with pantethine supplemented diets. There were significant increase in the

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hight density lipoprotein-cholesterol concentration and decrease in the atherogenic index in the plasma of the birds fed with the diet supplemented 200ppm of pantethine. The plasma triglycride concentration of the birds fed the diet supplemented with 100ppm of pantethine was significantly increased. The concentration of non-esterified fatty acid in the plasma of the birds fed with the pantethine supplemented diets was also significantly reduced. With increasing dietary pantethine levels, an increase in 17β-estradiol concentration in the plasma was observed. However, the plasma thyroxine concentration of the birds fed with the 200ppm pantethine supplemented diet was significantly decreased. There were no significant effects of pantethine supplementation on the liver triglyceride and phospholipid contents, and plasma phospholipid and glucose concentrations of the birds. Activities of citrate cleavage enzyme (EC 4, 1, 3, 8) as well as nicotinamide adenine dinucleotide phosphate-malate dehydrogenase (EC 1, 1, 1, 40) in the liver were significantly depressed as the diet was supplemented with pantethine but the activities of fatty acid synthetase was not significantly affected. Addition of pantethine to diet tended to reduce the activity of methyl-glutaryl-CoA reductase (EC 1, 1, 1, 34).