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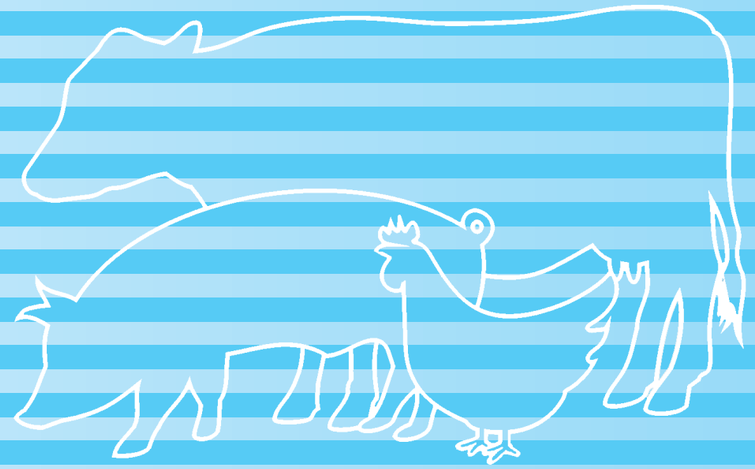

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飼糧粗蛋白質及代謝能含量對高肉質黑豬雜交肉豬生長性能之影響 (1)

王漢昇 (2)　李秀蘭 (3)　黃憲榮 (3)　王治華 (4)　林正鏞 (5)　許晉賓 (3)(6)

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摘　要

本研究旨在探討飼糧中不同粗蛋白質或代謝能含量對高肉質黑豬雜交肉豬生長期之生長性能與血液生化值影響，試驗分為兩部分進行，每試驗各進行 6 週試驗，每組以體重 30 kg 肉豬 16 頭進行，分為 4 欄，公母各半。試驗一以 30 kg 肉豬 64 頭探討代謝能 (Metabolizable energy, ME) 3,250 kcal/kg 與 3,100 kcal/kg 及粗蛋白質 (Crude protein, CP) 15.5% 與 14% 組成之 2 × 2 複因子試驗對豬隻生長之影響。試驗二以 30 kg 肉豬 48 頭進一步探討代謝能 3,250 kcal/kg 搭配粗蛋白質 18、16.5 及 15% 對豬隻生長之影響。試驗一結果顯示，試驗結束之體重，以粗蛋白質 15.5% 顯著 ($P < 0.05$) 大於粗蛋白質 14%，試驗全期之 ADG 以粗蛋白質 15.5% 極顯著 ($P < 0.01$) 大於粗蛋白質 14%，飼料轉換率 (Gain/Feed, G/F) 亦以粗蛋白質 15.5% 顯著 ($P < 0.05$) 大於粗蛋白質 14%。而第 4 週之血中尿素氮 (Blood urea nitrogen, BUN) 及肌酸酐 (Creatinine) 含量以粗蛋白質 15.5% 極顯著 ($P < 0.01$) 大於粗蛋白質 14%。試驗二結果顯示，提升粗蛋白質含量由 15% 至 18%，不影響試驗全期 ADG、平均每日採食量 (Average daily feed intake, ADFI) 及 G/F，而試驗於第 4 週之 BUN 以粗蛋白質 18% 顯著 ($P < 0.05$) 大於粗蛋白質 16.5%。綜合兩試驗結果，可發現粗蛋白質含量相較於 ME 含量，對生長期高肉質黑豬之生長性能有顯著影響，而於 ME 3,250 kcal/kg 之含量，以粗蛋白質含量 18% 則對生長性能無顯著增進之效果。

關鍵詞：粗蛋白質、代謝能、生長性能、血液生化值。

緒　言

高畜黑豬為使用梅山豬與杜洛克雜交而育成之黑豬品種 (許等，2011)，自 2009 年正式通過農委會審查命名為高畜黑豬並積極進行推廣，然經由業界之使用意見指出，其屠體品質及生長速率尚有改善空間，但繁殖性能優良及肉質鮮嫩屢獲業界肯定。為改善這些性狀，因此發展以杜洛克與高畜黑豬進行雜交，選育具多產基因 (MM)、抗緊迫基因 (AA) 及高肉質基因之有利基因型 (HH6)，遺傳組成含杜洛克血統 50%、高畜黑豬血統 50% 之高肉質品系 (命名中新品系－高肉質黑豬，英文簡寫 Q)。此一品種含梅山豬遺傳組成，故其在生長與營養利用上可能與一般商業常見之三品種雜交肉豬不盡相同，如同為本土豬種之蘭嶼豬，其離乳後使用粗蛋白質含量 16% 且不額外添加胺基酸之飼糧在生長性能較好，同時代謝能含量 3,100 kcal/kg 與 2,800 kcal/kg 相比則無顯著差異 (Chen *et al.*, 2017)，與 NRC (2012) 在代謝能上推薦之 3,300 kcal/kg 有別。三品種雜交肉豬較高肉質黑豬生長為快，對於營養需求較高；因高肉質黑豬生長較慢，若依目前之營養標準，可能會導致營養過剩問題，過剩之營養素無助於提升生長性能、屠體與肉質品質，甚至可能會降低生長 (Chen *et al.*, 1999)，或在排泄物中造成營養素的損失 (Just, 1982; Noblet *et al.*, 1987; Noblet *et al.*, 1994)。除此之外，近十年來陸續遭遇飼料原料價格波動及降低氮源浪費等友善環境之思維，生長期豬隻飼糧中若降低粗蛋白質含量且補充合成胺基酸可顯著減少氨之排放，亦不影響氮或肌肉之蓄積 (Alonso *et al.*, 2010; Figueroa *et al.*, 2012; Wang *et al.*, 2018; Zhang *et al.*, 2016)。

部分文獻也指出，當必需胺基酸於充足的狀態下，飼糧中的粗蛋白質及非必需胺基酸含量並不影響飼料效率以

(1) 行政院農業委員會畜產試驗所研究報告第 2655 號。
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及生長性能 (Kumar *et al.*, 2012; Liu *et al.*, 2019)，同時在離乳後保育豬，可有效降低粗蛋白質之使用且不影響生長性狀 (Gloaguen *et al.*, 2014) 及免疫指標 (Peng *et al.*, 2016)。Noblet *et al.* (1987) 在藍瑞斯生長期豬隻試驗中證實，若補充足夠之必需胺基酸，體內組織有較高之氮與較低之脂肪蓄積。此外，Noblet *et al.* (1994) 亦指出額外添加脂肪可降低豬隻飼養所產生之熱緊迫。Fraga *et al.* (2019) 發現於 22 － 30℃循環之環境中使用正常飼糧與高能量低粗蛋白質飼糧，每日交替餵飼於生長期豬隻，可獲得較好的平均日增重。因此在目前須符合高效能、環保及極端氣候之環境中，豬隻飼糧中之胺基酸、粗蛋白質及能量含量間的平衡相當重要。

由於高肉質黑豬帶有梅山豬遺傳組成 25%，故有必要對於其生長期合適營養需求進行探討，以減少不必要之氮源浪費以及能量消耗，同時符合環境友善之概念。國人傳統上喜好食用黑毛豬肉，而現今面臨疾病環伺與極端氣候頻仍之挑戰，黑豬飼養模式需要調整。因此本試驗目的即探討高肉質黑豬於生長期之營養濃度，以提供未來業者進行飼養時之參考。

材料與方法

I. 試驗飼糧配方設計

試驗配方係使用玉米－大豆粕為基礎原料，同時將離胺酸與甲硫胺酸調整至相同含量，試驗一採用不同粗蛋白質 (Crude protein, CP) 與代謝能 (Metabolizable energy, ME) 含量之 2 x 2 複因子試驗 (如表 1，CP 15.5% 係參考 NRC (2012) 於 20 － 50 kg 豬隻飼糧中總氮需求 x 6.25 所得，CP 14% 則由 CP 15.5% 調降 10% 所得)，飼糧分別為 HPHE (CP 15.5%、ME 3,250 kcal/kg)、LPHE (CP 14.0%、ME 3,250 kcal/kg)、HPLE (CP 15.5%、ME 3,100 kcal/kg) 及 LPLE (CP 14.0%、ME 3,100 kcal/kg)；試驗二則以上一試驗所探討生長較佳之代謝能 3,250 kcal/kg 搭配三種粗蛋白質含量 (如表 1)，飼糧分別為 G18 (CP 18.0%、ME 3,250 kcal/kg)、G16 (CP 16.5%、ME 3,250 kcal/kg) 及 G15 (CP 15.0%、ME 3,250 kcal/kg)。

表 1. 試驗飼糧配方及營養組成分

Table 1. The composition and calculated nutrient values of experimental diet

Ingredients	Experiment 1				Experiment 2		
	HPHE	LPHE	HPLE	LPLE	G18	G16	G15
Corn, ground	738.0	777.2	675.7	709.9	672.0	711.9	751.1
Soybean meal, 43.5%	197.7	156.9	193.3	153.1	265.6	224.9	184.1
Wheat bran	0.0	0.0	70.0	70.0	0.0	0.0	0.0
Limestone	9.0	9.2	10.2	10.0	9.2	9.1	9.1
Dicalcium phosphate	11.0	11.5	9.1	9.8	10.0	10.4	11.1
Fish meal, 65%	20.0	20.0	13.5	13.5	20.0	20.0	20.0
Choline chloride, 50%	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Molasses	0.0	0.0	16.0	20.0	0.0	0.0	0.0
Salt	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Soybean oil	12.4	11.8	0.0	0.0	13.7	12.8	12.2
Vitamin premix[a]	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mineral premix[b]	1.5	1.5	1.5	1.5	1.5	1.5	1.5
L-Lysine·HCl, 78%	3.1	4.4	3.3	4.6	1.0	2.2	3.5
DL-Methionine, 99%	0.3	0.5	0.4	0.6	0.0	0.2	0.4
Total	1,000.0	1,000.0	1,000.0	1,000.0	1,000.0	1,000.0	1,000.0
Calculated composition							
ME, kcal/kg	3,250	3,250	3,100	3,100	3,250	3,250	3,250
Lysine, %	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Methionine, %	0.32	0.32	0.32	0.32	0.32	0.32	0.32
CP, %	15.5	14.0	15.5	14.0	18.0	16.5	15.0

[a] Vitamin supplied the following per kilogram of diet: vitamin A, 6,000 IU; vitamin D_3, 400 IU; vitamin E, 20 IU; vitamin K_3, 2 mg; vitamin B_1, 2.6 mg; vitamin B_2, 2 mg; Niacin, 30 mg; Pantothenic acid, 30 mg; Pyridoxine, 3 mg; vitamin B_{12}, 0.6 mg; Biotin, 0.2 mg

[b] Mineral supplied the following per kilogram of diet: Fe ($FeSO_4 \cdot 7H_2O$，20.09% Fe), 80 mg; Cu ($CuSO_4 \cdot 5H_2O$, 25.45% Cu), 5 mg; Mn ($MnSO_4 \cdot H_2O$，32.49% Mn), 6 mg; Zn ($ZnSO_4$，80.35% Zn), 45 mg; I (KI), 0.2 mg; Se ($NaSeO_3$, 45.56% Se), 0.1 mg; Co ($CoSO_4 \cdot H_2O$，32% Co), 0.35 mg.

II. 試驗動物與飼養管理

兩部分試驗皆通過行政院農業委員會畜產試驗所高雄種畜繁殖場實驗動物照護及使用委員會審查通過，試驗一使用平均體重 30 kg 之高肉質黑豬 64 頭，逢機分配於 4 組試驗配方 (如表 1)，每組 16 頭，每 4 頭為一欄，公母各半，飼養於 3.25 m × 2.95 m 之欄舍中，試驗進行 6 週，試驗期間水及飼料採任飼；試驗二則使用平均體重 30 kg 之高肉質黑豬 48 頭，逢機分配於 3 組試驗配方 (如表 2)，每組 16 頭，每 4 頭為一欄，公母各半，飼養於 3.25 m × 2.95 m 之欄舍中，試驗進行 6 週，試驗期間水及飼料採任飼。

III. 生長試驗及血液生化值測定

生長期間，豬隻自試驗開始測定初始重量，之後於每兩週進行秤重以計算試驗期間之平均每日增重 (Average daily gain, ADG)，同時亦記錄採食量以計算試驗期間之平均每日採食量 (Average daily feed intake, ADFI) 及飼料轉換率 (Gain/Feed, G/F)。另於試驗開始、第 4 週及試驗結束時，經人工固定後進行頸靜脈採血，收集血液供測定血液生化值，測定項目包含尿素氮 (Blood urea nitrogen, BUN)、肌酸酐及三酸甘油酯 (Triacylglycerol, TG) 濃度。

IV. 統計分析

試驗收集之生長性能及血液生化值資料，使用 SAS 9.4 統計軟體之一般線性模式 (General linear model procedure, GLM) 進行變方分析，若產生顯著差異後試驗一以最小均方平均值法 (Least-square means, LSMEANS) 進行各處理組平均值差異之顯著性檢定，而試驗二以雪菲 S 法 (Scheffe's S method) 進行各處理組平均值差異之顯著性檢定。

結果與討論

I. 生長性能

試驗一以不同粗蛋白質及代謝能含量對 30 － 60 kg 高肉質黑豬之生長性能結果如表 2 所示，試驗結束之平均體重無顯著差異，但以 HPHE 在數據上的 64.6 kg 較高，試驗期間之 ADG、ADFI 及 G/F 亦無顯著差異，以 HPHE 在數據上有表現較好及較佳之趨勢，分別為 0.82 kg、2.23 kg 及 0.37。然因試驗之主效應無交感作用，故再進行探討主效應之影響，在 CP 主效應部分，試驗結束之平均體重以 CP 15.5% 顯著 ($P < 0.05$) 大於 CP 14%，而試驗期間之 ADG 以 CP 15.5% 極顯著 ($P < 0.01$) 大於 CP 14%，G/F 以 CP 15.5% 顯著 ($P < 0.05$) 大於 CP 14%，ADFI 則無顯著差異。在代謝能主效應部分，試驗結束之平均體重無顯著差異，試驗期間之 ADG、ADFI 及 G/F 則無顯著差異。

表 2. 飼糧粗蛋白質及代謝能含量對體重 30 － 60 kg 之高肉質黑豬生長性能影響[c] (試驗一)

Table 2. Main effects of different crude protein and metabolizable energy levels on the growth performance of 30 ~ 60 kg body weight Duroc x KHAPS black pig growers[c] (Exp. I)

Item	LPLE	HPLE	LPHE	HPHE	SEM	Significance		
						CP	ME	CP × ME
Initial BW, kg	30.2	30.4	30.7	30.2	0.66	NS	NS	NS
6 wk BW, kg	60.0	62.4	60.1	64.6	1.32	*	NS	NS
Total period								
ADG, kg	0.71	0.76	0.70	0.82	0.02	**	NS	NS
ADFI, kg	2.14	2.09	2.02	2.23	0.06	NS	NS	NS
Gain/Feed	0.33	0.36	0.35	0.37	0.01	*	NS	NS

[c] Values are means, n = 16.

LPLE: CP 14%, ME 3,100 kcal/kg; HPLE: CP 15.5%, ME 3,100 kcal/kg; LPHE: CP 14%, ME 3,250 kcal/kg; HPHE: CP 15.5%, ME 3,250 kcal/kg.

* $P < 0.05$, ** $P < 0.01$, NS: Not significant ($P > 0.05$).

試驗二以 3,250 kcal/kg 之代謝能配合不同粗蛋白質含量對生長期高肉質黑豬之生長性能結果如表 3 所示，試驗結束之平均體重無顯著差異，但以 G16 在數據上的 61.0 kg 較好，試驗期間之 ADG、ADFI 及 G/F 無顯著

差異，ADG 以 G16 在數據上的 0.73 kg 較高，ADFI 以 G15 在數據上的 1.89 kg 較高，G/F 則以 G16 及 G15 在數據上的 0.38 較佳。

表 3.　飼糧粗蛋白質含量對體重 30 － 60 kg 之高肉質黑豬生長性能影響 [c]（試驗二）

Table 3.　Effects of different crude protein levels on the growth performance of 30 ~ 60 kg body weight Duroc x KHAPS black pig growers[c] (Exp. II)

Item	G18	G16	G15	SEM
Initial BW, kg	30.5	30.4	30.2	0.85
6 wk BW, kg	59.6	61.0	60.0	1.31
Total period				
ADG, kg	0.69	0.73	0.71	0.02
ADFI, kg	1.87	1.87	1.89	0.07
Gain/Feed	0.36	0.38	0.38	0.01

[c] Values are means, n = 16.

G18: CP 18%, ME 3,250 kcal/kg; G16: CP 16.5%, ME 3,250 kcal/kg; G15: CP 15%, ME 3,250 kcal/kg.

Deng *et al.* (2007) 在 YD 閹公豬試驗發現，當補充離胺酸、羥丁胺酸及甲硫胺酸，同時將粗蛋白質由 18.2% 降低至 13.6% 時，體內之氮排放及氮蓄積皆顯著下降，同時氮表面消化率亦顯著下降；Li *et al.* (2017) 則在 LYD 生長期豬隻中發現，當補充離胺酸、羥丁胺酸、甲硫胺酸及色胺酸，同時將粗蛋白質由 20% 降低至 14% 時，背最長肌之游離胺基酸含量顯著降低，Yue and Qiao (2008) 在 LY 離乳仔豬飼糧中降低粗蛋白質 4% 同時補充色胺酸、異白胺酸、纈胺酸、組胺酸及苯丙胺酸，ADG 及 F/G 顯著降低，Roux *et al.* (2011) 在 20 － 45 kg 之 LY 與 LYD 豬隻飼糧中將粗蛋白質由 18.18% 降低至 13.34%，同時補充離胺酸、羥丁胺酸、甲硫胺酸及色胺酸，其 ADG 及 G/F 顯著降低。在本試驗一中，CP 15.5% 之第 6 週平均體重及 G/F 顯著高於 CP 14%，而 ADG 極顯著高於 CP 14%，與上述文獻結果類似，顯示以 CP 含量 14% 時，補充離胺酸與甲硫胺酸對高肉質黑豬生長期之生長並未獲得與 CP 15.5% 之生長效果，可能需要額外補充其他種類之合成胺基酸或提升粗蛋白質含量，以維持高肉質黑豬生長期之生長性能。

試驗二則以 CP 15% 為基礎，同時固定離胺酸及甲硫胺酸含量與試驗一相同，逐步提升粗蛋白質含量以釐清是否在添加此二種合成胺基酸下與粗蛋白質梯度產生影響，結果發現，提升粗蛋白質含量對生長性能無顯著增進效果。Noblet *et al.* (1987) 指出在 20 kg 約克夏生長豬試驗中，使用 CP 含量 15% 會較 CP 含量 18%，在飼養 7 週後有較低之體重，但使用 CP 含量 15%，同時補充離胺酸至 CP 含量 18%，則不影響體重、肌肉增加量及氮蓄積量，此結果與本試驗二發現類似，當 G15 添加離胺酸與 G18 一致時，其生長性能無顯著差異。Kerr *et al.* (1995) 指出 20 kg 之 LYH 雜交肉豬使用 CP 12%，同時補充離胺酸、羥丁胺酸、色胺酸，結果發現與使用 CP 16% 之組別在生長性狀無顯著差異；而 Kerr and Easter (1995) 則發現在 18 kg 藍瑞斯系雜交肉豬試驗中降低 CP 含量同時補充必需胺基酸可達到增加氮蓄積之作用；Figueroa *et al.* (2012) 在比利華雜交閹公豬生長期中降低 CP 含量 2.5% 並提升離胺酸至 0.93% 時可有效恢復 ADG 及 ADFI，由上述文獻結果可發現，當補充不同種類人工合成胺基酸至一定濃度時，低 CP 含量在生長性狀部分可與高 CP 組產生相似之效果，而試驗二中僅補充離胺酸與甲硫胺酸即可達到與粗蛋白質 18% 相同之生長效果，顯見高肉質黑豬在此營養濃度下，添加兩種胺基酸已可滿足生長需求。然而，也由上述各文獻中顯示對於補充胺基酸同時降低粗蛋白質含量對於豬隻生長或代謝之結果仍不一致，對於不同品種、成長階段、環境、飼糧之不同胺基酸添加種類與含量及降低粗蛋白質之程度皆會影響試驗結果，因此在使用低粗蛋白質飼糧時，對於各項條件均須逐一檢視。

而在有關豬隻能量部分，Nieto *et al.* (2002) 在伊比利黑豬生長期試驗中發現降低飼糧中之 CP 至 129 g/kg DM 可獲得最佳之蛋白質與能量蓄積。Smith *et al.* (1999) 發現使用精選白脂 (Choice white grease) 在 44.5 － 73 kg 之生長期豬隻中提升能量含量至 3.56 Mcal/kg 不影響 ADG 表現，但 ADFI 顯著下降、飼料效率顯著改善；在 29.5 － 72.6 kg 間提升能量含量至 3.57 Mcal/kg 亦顯著降低 ADFI 且顯著改善飼料效率。在試驗一可發現在代謝能主效應部分，ADFI 及 G/F 未有與文獻一致之發現。此外，由表 2 中可發現在試驗期間 ADG 及 ADFI 皆以 LPHE 低於 HPHE，Kuan *et al.* (1986) 指出在平均體重 20 － 50 kg 之生長期 LYD 雜交肉豬使用不同之蛋白能量比，ADG 隨著比值提升而顯著增加，以本試驗而言，HPHE 之蛋白能量比較 LPHE 高，兩者間 ADG 呈現如文獻所稱之趨勢；Bowland and Berg (1959) 則是發現生長期豬隻於高能量高粗蛋白質飼糧下有最大之每日採食量，

此一發現也與本試驗於試驗期間 ADFI 所發現之結果相似。由試驗一及試驗二之生長性能發現，對於生長期之高肉質黑豬而言，在固定離胺酸含量於 1.05% 情況下，提升粗蛋白質含量至 18% 對生長性能無顯著增進之效果。

II. 血液生化值

試驗一以不同粗蛋白質及代謝能含量對 30 － 60 kg 高肉質黑豬之血液生化值結果如表 4 所示，第 4 週與試驗結束之尿素氮 (BUN)、肌酸酐及三酸甘油酯 (TG) 無顯著差異。然因試驗之主效應無交感作用，故再進行探討主效應之影響，在 CP 主效應部分，第 4 週之 BUN 及肌酸酐以 CP 15.5% 極顯著 ($P < 0.01$) 大於 CP 14%，TG 則無顯著差異，而試驗結束之 BUN、肌酸酐及 TG 無顯著差異。在代謝能主效應部分，第 4 週與試驗結束之 BUN、肌酸酐及 TG 無顯著差異。試驗二以 3,250 kcal/kg 之代謝能配合不同粗蛋白質含量對生長期高肉質黑豬之血液生化值結果如表 5 所示，第 4 週之 BUN 以 G18 的 12.98 mg/dL 顯著 ($P < 0.05$) 大於 G16 的 7.10 mg/dL，肌酸酐及 TG 無顯著差異；而試驗結束之 BUN、肌酸酐及 TG 無顯著差異。

表 4. 飼糧粗蛋白質及代謝能含量對體重 30 － 60 kg 之高肉質黑豬血液生化值之效應[c] (試驗一)

Table 4. Main effects of different crude protein and metabolizable energy levels on the blood parameters of 30 ~ 60 kg body weight Duroc x KHAPS black pig growers[c] (Exp. I)

Item	LPLE	HPLE	LPHE	HPHE	SEM	Significance		
						CP	ME	CP × ME
Initial	10.19	10.75	8.95	8.81	0.72	NS	NS	NS
BUN, mg/dL	0.95	0.98	0.93	0.98	0.04	NS	NS	NS
Creatinine, mg/dL	35.00	26.88	30.00	32.25	3.54	NS	NS	NS
Triacylglycerol, mg/dL								
4th wk	6.86	12.15	6.80	8.59	0.90	**	NS	NS
BUN, mg/dL	1.03	1.21	1.04	1.10	0.03	**	NS	NS
Creatinine, mg/dL	36.00	44.00	31.25	30.75	5.36	NS	NS	NS
Triacylglycerol, mg/dL								
6th wk	7.31	9.70	7.31	8.60	0.90	NS	NS	NS
BUN, mg/dL	1.14	1.14	1.15	1.10	0.04	NS	NS	NS
Creatinine, mg/dL	31.00	26.88	29.00	32.63	2.42	NS	NS	NS
Triacylglycerol, mg/dL	0.33	0.36	0.35	0.37	0.01	*	NS	NS

[c] Values are means, n = 32.

LPLE: CP 14%, ME 3,100 kcal/kg; HPLE: CP 15.5%, ME 3,100 kcal/kg; LPHE: CP 14%, ME 3,250 kcal/kg; HPHE: CP 15.5%, ME 3,250 kcal/kg.

* $P < 0.05$, ** $P < 0.01$, NS: Not significant ($P > 0.05$).

本試驗無論在試驗一或試驗二，各組之 BUN、肌酸酐及 TG 皆在正常範圍內 (Klem *et al.*, 2010)。在試驗一結果可發現在第 4 週時 BUN 受 CP 主效應影響，且以 CP 15.5% 顯著高於 CP 14%，試驗二亦發現在第 4 週時 BUN 以 G18 顯著高於 G16，此結果與 Powell *et al.* (2011) 在約克夏雜交肉豬及 Fernández-Fígarez *et al.* (2007) 在藍瑞斯與伊比利黑豬生長期進行高低粗蛋白質含量試驗中所得結果一致，高 CP 會造成豬隻有較高之 BUN 產生，但於試驗結束時雖亦呈現此一趨勢但未達顯著差異。Cai *et al.* (1995) 則指出豬隻攝取較多能量時其血漿中尿素氮會顯著降低，主要因在低能量攝取會使豬隻利用氧化胺基酸產生能量，如此會使得尿素氮上升，此一發現也與本試驗一在第 4 週與試驗結束時高代謝能處理較低代謝能處理之尿素氮低相符，由於血液中之尿素氮為飼糧中粗蛋白質之代謝產物，若血液中尿素氮降低則可視為減少氮源之排放 (Wang *et al.*, 2018)，因此以低粗蛋白質飼糧或提供粗蛋白質 16.5% 之飼糧對於減低氮源排放較有幫助；另外在第 4 週時同樣可發現肌酸酐受 CP 主效應影響，且以 CP 15.5% 顯著高於 CP 14%。根據 Baxmann *et al.* (2008) 指出，血清肌酸酐含量隨體重增加、脂肪含量下降、瘦肉率增加及活動量增加而上升，由於 CP 15.5% 於試驗期間平均每日增重確實有較高之趨勢，使得同一時間點下其平均重量較高，因此也導致肌酸酐顯著提升，此部分與文獻發現一致。

綜觀試驗一結果，可發現 CP 含量相較於 ME 含量，對高肉質黑豬生長期性能有顯著影響，而在試驗二則發現，在補充離胺酸至 1.05% 情況下，使用 ME 3,250 kcal/kg 搭配 CP 18% 並無法顯著增進生長表現。

表 5.　飼糧粗蛋白質含量對體重 30 － 60 kg 之高肉質黑豬血液生化值之效應 [c] (試驗二)

Table 5.　Effects of different crude protein levels on the blood parameters of 30 ~ 60 kg body weight Duroc × KHAPS black pig growers[c] (Exp. II)

Item	G18	G16	G15	SEM
Initial				
BUN, mg/dL	9.31	9.25	8.50	1.05
Creatinine, mg/dL	0.94	0.95	0.98	0.04
TG, mg/dL	40.00	32.00	47.38	6.45
4th wk				
BUN, mg/dL	12.98a	7.1b	8.24ab	1.34
Creatinine, mg/dL	1.08	1.06	1.14	0.05
TG, mg/dL	37.25	35.25	30.50	3.21
6th wk				
BUN, mg/dL	13.61	10.38	12.65	1.65
Creatinine, mg/dL	1.23	1.24	1.20	0.05
TG, mg/dL	33.50	36.50	32.50	3.34

[a, b] Means with the different superscripts differ significantly ($P < 0.05$).

[c] Values are means, n=16.

G18: CP 18%, ME 3,250 kcal/kg; G16: CP 16.5%, ME 3,250 kcal/kg; G15: CP 15%, ME 3,250 kcal/kg.

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Effects of dietary crude protein and metabolizable energy levels on the growth performance of Duroc x KHAPS black pig in growing period [1]

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Abstract

Two trials were conducted to investigate the effects of dietary different crude protein (CP) and metabolizable energy (ME) levels on the growth performance and blood parameters of Duroc x Kaohsiung Animal Propagation Station black pig (DK black pigs) during growing period. In each trial, sixteen pigs (eight males and eight females) were randomly allotted to different diets and were fed for six weeks. In experiment 1, sixty-four pigs (30 kg BW) were assigned to one of the dietary treatments in a 2 × 2 factorial arrangement with two CP levels (14% and 15.5%) and two ME levels (3,100 kcal/kg and 3,250 kcal/kg). In experiment 2, forty-eight pigs (30 kg BW) were assigned to one of the three dietary CP treatments (18%, 16.5% and 15%) to assess the effect of higher CP levels under 3,250 kcal/kg ME. In experiment 1, the results showed that the average body weight in CP 15.5% was higher ($P < 0.05$) than CP 14%. The average daily gain (ADG) of CP 15.5% was higher ($P < 0.01$) than CP 14% and the Gain/Feed (G/F) of CP 15.5% was higher ($P < 0.05$) than CP 14%. The blood urea nitrogen (BUN) and creatinine in CP 15.5% at the 4th week were higher ($P < 0.01$) than CP 14%. In experiment 2, the results showed that the increase of CP levels did not influence the ADG, Average daily feed intake and G/F during the whole experimental period. The BUN in CP 18% at the 4th week was higher ($P < 0.05$) than CP 16.5%. In conclusion, the CP level was more important than ME level on the growth performance while the diet with CP 18% did not improve the growth performance of DK black pig growers.

Key words: Crude protein, Metabolizable energy, Growth performance, Blood parameters.

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植物多醣萃取物對離乳仔豬生長性狀、糞便菌相與發炎因子的效應 (1)

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摘　要

本試驗目的在評估飼糧添加 0.1% 之麩皮、苜蓿粉 (簡稱苜蓿) 或狼尾草台畜草 3 號 (簡稱狼尾草) 多醣萃取物對離乳仔豬生長性能、糞便微生物群與抗發炎之效應。試驗動物採用 4 週齡離乳之 LYD 三品種雜交肉仔豬 32 頭 (公母各半)，依體重與性別，分為 4 處理組，分別飼養於 16 個保育欄舍中，每欄均為 1 公 1 母，進行為期 4 週之試驗。基本飼糧營養濃度含 18% 粗蛋白質與 3,500 kcal/kg 可消化能，此外分別添加 0.1% 之麩皮、苜蓿或狼尾草多醣萃取物為試驗組，對照組豬隻餵飼基本飼糧。在 3 種植物多醣萃取物含量，以苜蓿多醣萃取物最低，佔全乾重 (Dry matter) 之 9.0%；麩皮次之，為 11.6%；狼尾草最高，為 17.9%。試驗結果顯示，仔豬於離乳後第 4 週體重，餵飼添加 0.1% 狼尾草多醣萃取物比添加 0.1% 麩皮多醣萃取物飼糧組顯著較重 ($P < 0.05$)；仔豬於離乳後第 1 週，餵飼添加 0.1% 狼尾草多醣萃取物者，比添加 0.1% 麩皮多醣萃取物飼糧組，飼料效率顯著較佳 ($P < 0.05$)，而試驗全期 (離乳後 1 － 4 週) 亦是以餵飼添加 0.1% 狼尾草多醣萃取物比對照組有顯著 ($P < 0.05$) 較佳的飼料效率。在抗發炎的作用，以餵飼離乳仔豬添加 0.1% 狼尾草、苜蓿及麩皮之多醣萃取物飼糧，分別具有抑制 3 種發炎因子 (IL-1β、IL-6 及 IL-8)、2 種 (IL-6 與 IL-8) 以及 1 種 (IL-1β) 的作用。對於仔豬糞便菌相的影響，餵飼添加 0.1% 之狼尾草多醣萃取物飼糧，在離乳後第 15 與 28 天，抑制仔豬糞便大腸桿菌數之效果顯著大於對照組，同時在離乳後第 15 天時，仔豬糞便乳酸菌數亦顯著 ($P < 0.05$) 較對照組高。綜合而言，在離乳仔豬飼糧添加 0.1% 狼尾草多醣萃取物，可以改善離乳後第 4 週每日增重與全期 (離乳後 1 － 4 週) 的飼料效率，同時有助於降低發炎因子以及增加糞便乳酸菌數。另外，添加 0.1% 麩皮或 0.1% 苜蓿多醣萃取物，亦有降低相關的發炎因子的作用。

關鍵詞：植物多醣、萃取物、腸道微生物。

緒　言

雜食性豬隻在大腸部位 (特別是盲腸與結腸) 的發酵作用所產生揮發性脂肪酸，可以提供豬隻 5 － 28% 的能量需要量 (Kass *et al.*, 1980; Klavs *et al.*, 1992)。同時大腸之微生物菌相，對豬隻腸道健康扮演非常重要角色，由於微生物產生之短鏈脂肪酸 (如甲酸、乙酸、丙酸及酪酸等)，抑制有害微生物之增殖，具有保護結腸與直腸之作用 (Blottiere *et al.*, 2003; Anguita *et al.*, 2006; Biagi *et al.*, 2006)。豬隻後腸 (Hindgut) 部位之多醣來源，絕大部分來自飼糧，且是屬於非水溶性的植物纖維，包括有植物細胞壁多醣、寡糖、儲藏性多醣例如菊澱粉 (Inulin) 與抗性澱粉等 (Cherbut, 2002)。其他植物性的細胞壁如木聚糖 (Xylan) 與果膠 (Pectin) 則是可以從植物結構中釋放出來，並形成水溶性纖維，這些多樣性之多醣，具有影響豬隻腸道菌相的作用 (Cherbut, 2002)。非水溶性纖維素在大腸中的作用像大量微細刷子，把大腸內的宿便殘渣掃除，幫助淨化腸道系統以及促進正常排便的功能 (Reid *et al.*, 2003)。非水溶性纖維素亦具有促進腸道益生菌生長與增殖的作用，由於纖維素在腸道中可以成為腸道微生物之營養素來源 (Schnabel *et al.*, 1983)，讓腸道內多種的細菌數量快速增殖，其中包括好氧性與厭氧性的菌種 (William *et al.*, 1991)。動物腸道中菌相的平衡，常受到外來物質的干擾，如飼糧中添加抗生素。另外，可以被篩選與運用之腸道微生物飼料添加物，其中又以乳酸菌類及其產生的代謝成分最為普遍 (Yao *et al.*, 2016)。因此，本試驗運用由麩皮、苜蓿粉以及狼尾草作為多醣萃取物的來源，評估其對離乳仔豬生長性能、腸道微生物菌相及誘發發炎細胞激素濃度等影響。

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材料與方法

本試驗於行政院農業委員會畜產試驗所營養組試驗豬舍進行，試驗動物之使用、飼養管理及試驗內容經畜產試驗所實驗動物管理小組以畜試動字 104-25 號申請核准在案。

I. 試驗動物與飼糧處理

飼糧添加之植物多醣萃取物為源自麩皮、苜蓿粉及狼尾草台畜草三號，試驗動物採用 4 週齡離乳之 LYD 三品種雜交肉仔豬共 32 頭 (公母各半)，依體重與性別，分為 4 處理組，分別飼養於 16 個保育欄舍中，每欄均為 1 公 1 母，每組 4 重複，進行為期 4 週之試驗。對照組飼糧含 18% 粗蛋白質與 3,500 kcal/kg 可消化能，另分別添加 0.1% 之麩皮、苜蓿粉或狼尾草多醣萃取物為試驗組，對照組飼糧組成，如表 1 所示。試驗期間採任食，並充分供應飲水。每週量秤體重與記錄採食量一次、在試驗日開始與結束日以人工固定方法，由頸靜脈採集血液 10 mL 供分析免疫球蛋白與細胞激素含量用、採集仔豬糞便樣品 (分別於試驗開始日、離乳後第 15 天與試驗結束日) 供分析腸道微生物之菌相，評估植物多醣萃取物對改善仔豬生長性能、糞便菌相與抗發炎的效果。

表 1. 離乳仔豬飼養試驗之飼糧組成 (對照組)

Table 1. Composition of basal diets for postweaning piglet (control)

Ingredients, kg	Basal diet	Basal diet + Plant polysaccharide
Corn (yellow) (CP 7.5%)	597.3	596.3
Soybean meal (CP 43.5%)	200.0	200.0
Limestone (pulverized)	10.0	10.0
Dicalcium phosphate	15.0	15.0
Fish meal (CP 65%)	50.0	50.0
Skim milk (powder)	50.0	50.0
Whey	50.0	50.0
Choline-Cl (50%)	1.2	1.2
Soybean oil	20.0	20.0
Salt (iodized)	4.0	4.0
Vitamin premix[a]	1.0	1.0
Mineral premix[b]	1.5	1.5
Plant polysaccharidec		1.0
Total	1,000.0	1,000.0
Calculated value		
Digestible energy kcal/kg	3,522	3,522
Analyzed value %		
Crude protein	18.96	18.86
Lysine	1.17	1.18
Calcium	0.85	0.86
Total phosphorus	0.63	0.65

[a] Supplied the following vitamins per kg of diet: Vitamin A, 6,000 IU; Vitamin D_3, 800 IU; Vitamin E, 20 IU; Vitamin K_3, 4 mg; Vitamin B_1, 2 mg; Vitamin B_2, 4 mg; Vitamin B_6, 1 mg; Vitamin B_{12}, 0.02 mg; Niacin, 30 mg; Calcium pantothenate, 16 mg; Folic acid, 0.6 mg; Biotin, 0.01 mg and Choline chloride, 50 mg and Cobalt (II) sulfate heptahydrate 0.5 mg.

[b] Supplied the following minerals per kg of diet: Fe, 140 mg; Cu, 7 mg; Mn, 20 mg; Se, 0.15 mg; Zn, 120 mg; I, 0.45 mg.

[c] Added 0.1% extracted polysaccharide from wheat bran or alfalfa meal and napiergrass.

II. 植物多醣的萃取及萃取物多醣含量分析

植物多醣的萃取方法，乃參考 Baets and Vandamme (2001) 方法，進行麩皮、苜蓿及狼尾草 (*Pennisetum purpureum* Taishu No. 3) 等植物多醣的萃取，包括粉碎、稀釋、調整酸鹼度、加熱、過濾與酒精沉澱等步驟。因進行離乳仔豬的飼養試驗，需要較大量植物多醣萃取物。因此，在植物多醣萃取物的沉澱與收集等步驟，則採用 2 公升玻璃分液漏斗，其餘步驟均相同。

萃取物多醣含量分析，主要利用多醣的還原性特性，以 3,5-dinitrosalicylic acid (DNS) 試劑具有還原力之特性，當碳水化合物具有游離之醛或酮基，即能在鹼性溶液下產生還原能力，將 DNS (黃色) 還原成 3-amino-5-nitrosalicylic acid (橘紅色)，顏色深淺則與還原醣濃度成正比，並以波長 540 nm 測定吸光值。葡萄糖標準溶液之製備取 5 支試管，分別加入 1,000 mg/mL 標準葡萄糖液 1、2、4、6 及 8 mL 以及蒸餾水 9、8、6、4 及 2 mL，配製 100 － 800 μg/mL 的標準溶液，建立葡萄糖檢量線。接續進行樣品多醣含量分析，利用測得之吸光值，計算植物萃取物之多醣含量 (%) 公式如下：

$$\text{多醣含量 (\%)} = \frac{\text{葡萄糖濃度 (μg/mL)} \times \text{萃取液 (mL)}}{\text{樣品重 (g)} \times \text{乾物率 (\%)}} \times 100\%$$

III. 豬糞便中菌相的分析

參照 Lactobacilli MRS Medium (Difco™ & BBL™ Manual, 2nd Edition; https://legacy.bd.com/europe/regulatory/Assets/IFU/Difco_BBL/288 110.pdf) 方法分析乳酸菌數，秤取 1 g 糞便先放入 10 mL 0.85% NaCl 混合均勻，接續用 0.85% NaCl 連續稀釋 (1 mL + 9 mL 0.85%NaCl) 至 1/1,000,000，共稀釋 5 次。再以 L 型玻棒均勻塗抹至 Lactobacilli MRS 平面培養基 (Difco™ Lactobacilli MRS Agar) 上，之後置入 CO_2 培養箱，在微厭氧的環境下 (13% CO_2)，於 37℃培養 48 小時，最後根據菌落的大小與形態挑出單獨菌落。

豬隻糞便中大腸桿菌 (*Escherichia coli*)、其他大腸桿菌群 (Other *Coliform*) 與其他腸內菌 *(*Other *Enterobacter)* 分析方法，參照 CHROMagar™ ECC 建議步驟。首先秤取 1 g 糞便先放入 10 mL 之 0.85% NaCl 混合均勻，接續用 0.85% 之 NaCl 連續稀釋 (1 mL + 9 mL 0.85% NaCl) 至 1/1,000,000，共稀釋 5 次。依照 CHROMagar agar 推薦用量調配適當濃度培養基，再分別用微波加熱後放置於冰箱中待用，注意培養基加熱溫度不可以完全沸騰，同時要注意培養基需使用褐色血清瓶盛裝藉以避光。兩項培養基，使用前亦須先使用微波加熱後 (不可以超過 100℃) 放置於 48℃水浴槽中備用。樣品接種方式，再以 L 型玻棒均勻塗抹至培養皿上，分別取 1 mL 之 1/1,000 及 1/1,000,000 稀釋糞便樣品，再分別注入 3 個 9 cm 培養皿，接續注入適量培養基 (約 9 mL)，搖放均勻靜置至凝固後，放置於 37℃培養箱經 24 小時後，計算菌落之數量，菌落呈藍色屬大腸桿菌、呈紫紅色 (Mauve) 屬其他大腸桿菌群以及呈蒼白色 (Colorless) 屬其他腸內菌。其呈色機制因大腸桿菌群為革蘭氏陰性好氣性或通氣嫌棄性桿菌，包括大腸桿菌 (*E. coli*) 與腸內菌等。大腸桿菌群能產生半乳糖苷酶 (β-galactosidase) 將產色基質 (Chromogen) X-gal (5-bromo-4- hloro-3-indolyl-beta-D-galactopyranoside；是 β-galactosidase 的反應受質) 作用使菌落呈紅色外觀；另外大腸桿菌產生 β- 葡萄醣醛酸酶 (β-glucuronidase) 能將產色基質 BCIG (5-bromo-4-chloro-3-indoxyl-β-D- glucuronide, BCIG) 作用使菌落外貌呈藍色。

IV. 血液免疫球蛋白含量的分析

以含有乙二胺四乙酸 (Ethylenediaminetetraacetic acid, EDTA) 抗凝血劑的採血管，抽取試驗豬頸靜脈竇之血液樣品，經離心 10 分鐘 (在 4℃、3,000 rpm 條件下)，收集血漿樣品並儲放於 -20℃冷凍櫃，供分析免疫球蛋白含量。血清免疫球蛋白 IgA、IgG 及 IgM 含量之測定，採用酵素鍵結免疫吸附法 (Enzyme-linked immunosorbent assay, ELISA)，依照製造廠商生產之 Pig ELISA 免疫球蛋白 (Immunoglobulin, Ig) IgA、IgM 及 IgG 分析套組 (Leinco Technologies, Inc, USA) 建議之步驟，並以波長 450 nm 進行含量分析。

V. 血液細胞激素含量的分析

參考 Pereira *et al.* (2012) 分析細胞激素方法，血液細胞激素偵測原理類似 ELISA，主要是利用抗體抗原免疫鍵結原理來偵測，Milliplex 則是將分析用抗體鍍膜在微珠上，藉由混合紅光及遠紅外光螢光染劑，混合成多種的顏色編碼 (Color - code)。每一種顏色編碼微珠接上具專一性辨識特定蛋白的抗體，來辨識血液樣品中細胞激素的特定蛋白，然後與標誌生物素 (Biotin) 的偵測抗體作用，最後加入 SAPE (Streptavidin phycoerythrin) 螢光抗體反應，以 Luminex 200 型機器 (Luminex Corporation, USA) 進行血液樣品中的 TNF-α (Tumor Necrosis Factor-α) 及介白素 (Interleukin, IL)、IL-1β、IL-6、IL-8 與 IL-10 等細胞激素濃度的偵測。

VI. 統計分析

試驗所得之各項資料，採用 SAS (2005) 的統計軟體，依 GLM 程序 (General linear model procedure) 進行變方分析，並以鄧肯氏多變域測定法 (Duncan's multiple range test) 進行處理組平均值間之差異顯著性分析，當 $P < 0.05$ 表差異顯著。

結果與討論

I. 麩皮、苜蓿與狼尾草之多醣萃取物含量

試驗採用的植物多醣萃取物，分別為畜禽飼料常用之植物性飼料原料麩皮 (麥類副產物)、苜蓿 (豆科植物) 及狼尾草台畜草三號 (牧草) 各 100 g。萃取方法包括三種飼料原料的粉粹、稀釋、調整 pH 值、熱水煮沸 2 小時、上清液經減壓濃縮後以 4 倍體積之 95% 酒精沉澱 24 小時與低溫烘乾等步驟。本研究所得 3 種粗多醣經還原糖定量法 (Dinitrosalicylic acid, DNS) 分析結果，以苜蓿多醣萃取物最低，麩皮次之，狼尾草最高，其多醣含量分別為 9.0%、11.6% 及 17.9%。狼尾草台畜草三號多醣萃取物較高之原因，可能因苜蓿與麩皮的粗蛋白質與酸洗纖維含量高於狼尾草台畜草三號所致 (臺灣飼料成分手冊，2011)。另外，國內一些萃取植物多醣研究中，採用之水萃取與酒精沈澱的方法，在金線蓮多醣萃取物其多醣含量為 14.81% (林，2009)，顯示本試驗採用的萃取植物多醣的方法，可以有效萃取苜蓿、麩皮及狼尾草等植物的多醣成分。

II. 飼糧添加 0.1% 植物多醣萃取物對離乳仔豬生長性狀之影響

以對照組不添加或分別添加 0.1% 麩皮、苜蓿或狼尾草植物多醣萃取物飼糧餵飼，仔豬體重在離乳後第 7、14、21 及 28 天時，4 組飼糧組間沒有顯著差異。但餵飼添加 0.1% 植物多醣萃取物之處理組，體重有高於對照組的趨勢 (表 2)。此現象可能因仔豬腸道微生物可以利用添加之植物多醣，產生揮發性脂肪酸具有提升仔豬體重的效果 (Noblet and Shi, 1994)。在離乳後第 4 週之日增重，餵飼添加 0.1% 狼尾草多醣萃取物比添加 0.1% 苜蓿多醣萃取物飼糧組，仔豬的日增重顯著較高，其他包括離乳後第 1、2、3 週及全期，則 4 組飼糧間沒有顯著差異 (表 3)。此項結果可能因仔豬腸道微生物對狼尾草多醣萃取物的利用，隨餵飼天數的增加而提高，進而在離乳後第 4 週達到顯著改善的效果。另外，此結果也顯示，狼尾草台畜草三號不僅含有較高量的多醣萃取物，同時多醣萃取物對改善離乳仔豬日增重效果，亦較優於苜蓿多醣萃取物。雖然添加狼尾草多醣萃取物組無法顯著地比對照組具有提升離乳仔豬的日增重，但是仍有提升離乳仔豬日增重 40 － 100 g 的效果。

表 2.　飼糧中添加 0.1% 不同植物多醣對 LYD 離乳仔豬體重的影響 §

Table 2.　Effect of adding 0.1% different kind of plant polysaccharide on bodyweight of LYD weaned pigs

Items Time	Control (C)	C+ 0.1% wheat bran polysaccharide	C+ 0.1% alfalfa meal polysaccharide	C+ 0.1% taishu No. 3 polysaccharide
No.	8	8	8	8
28-d-old, kg	7.45 ± 0.71*	7.72 ± 0.80	7.52 ± 0.76	7.98 ± 0.90
35-d-old, kg	9.36 ± 0.96	9.45 ± 2.01	9.60 ± 1.33	10.24 ± 1.75
42-d-old, kg	11.88 ± 1.52	12.25 ± 2.43	12.11 ± 1.76	13.07 ± 1.70
49-d-old, kg	14.62 ± 2.77	15.19 ± 3.31	15.32 ± 2.85	16.51 ± 2.49
56-d-old, kg	18.89 ± 3.11	19.47 ± 3.80	19.44 ± 3.69	21.38 ± 2.70

* Mean ± SD.

§ There were not significantly difference in body weight among those aged form 28 to 56-d-old by adding plant polysaccharide extracts.

飼料採食量方面，於 4 飼糧組間，雖然沒有顯著差異 (表 3)，但由表中可發現，餵飼添加 0.1% 植物多醣萃取物飼糧，仔豬的飼料採食量略低。此部分可能因飼糧中添加多醣萃取物具有增加飽足感的作用，造成仔豬的採食量有降低現象。

飼料效率方面，離乳後第 1 週期間，餵飼添加 0.1% 狼尾草多醣萃取物，顯著較餵飼 0.1% 麩皮多醣萃取物之仔豬飼料效率為佳 (表 3)，全期亦以餵飼添加 0.1% 狼尾草多醣萃取物，較對照組仔豬之飼料效率為佳。顯示餵飼狼尾草多醣萃取物，具有提升仔豬飼料效率的作用，此結果和 Verschuren *et al.* (2018) 者相同。前述現象可能因仔豬腸道需要一段時間適應多醣萃取物的消化作用，讓仔豬腸道微生物可以利用多醣產生揮發性脂肪酸 (Durmic *et al.*, 1998)。而這些短鏈脂肪酸，除可以促進仔豬腸道的健康，更可以作為仔豬能量來源 (Anguita *et al.*, 2006)。因此，離乳仔豬餵飼添加 0.1% 狼尾草多醣萃取物飼糧，有改善離乳仔豬飼料效率的作用。

III. 飼糧添加 0.1% 植物多醣萃取物對離乳仔豬血液免疫球蛋白與細胞激素含量之影響

餵飼離乳仔豬空白料或分別添加 0.1% 之 3 種植物多醣萃取物飼糧。不過在試驗結束時比試驗開始時，仔豬在 IgG、IgA 及 IgM 濃度有顯著增加之現象 (表 4)。在一些文獻中亦有類似的結果 (Curtis and Bourne, 1973; Wilson, 1974; Lee *et al.*, 2017; 劉等，2017)。此現象可能因試驗仔豬於 6 週齡 (離乳後第 15 天) 依照飼養管理步驟施打豬瘟與豬丹毒疫苗各一劑，進而造成仔豬免疫球蛋白濃度增加。

表 3. 飼糧中添加 0.1% 不同植物多醣對 LYD 離乳仔豬生長性狀的影響

Table 3. Effect of adding 0.1% different kind of plant polysaccharide on growth performance of LYD weaned pigs

Items Time	Control (C)	C+ 0.1% wheat bran polysaccharide	C+ 0.1% alfalfa meal polysaccharide	C+ 0.1% taishu No. 3 polysaccharide
No.	8	8	8	8
ADG, kg[x]				
1st week, kg	0.27 ± 0.04[*]	0.25 ± 0.17	0.29 ± 0.07	0.32 ± 0.10
2nd week, kg	0.36 ± 0.10	0.40 ± 0.07	0.36 ± 0.08	0.40 ± 0.03
3rd week, kg	0.39 ± 0.22	0.42 ± 0.19	0.46 ± 0.21	0.49 ± 0.15
4th week, kg	0.61 ± 0.05[ab]	0.61 ± 0.03[ab]	0.59 ± 0.06[b]	0.70 ± 0.05[a]
Overall, kg	0.41 ± 0.10	0.42 ± 0.08	0.43 ± 0.10	0.48 ± 0.05
ADFI, kg[y]				
1st week, kg	0.43 ± 0.10	0.45 ± 0.04	0.43 ± 0.19	0.44 ± 0.12
2nd week, kg	0.77 ± 0.25	0.75 ± 0.22	0.71 ± 0.20	0.72 ± 0.19
3rd week, kg	0.89 ± 0.36	0.87 ± 0.36	0.89 ± 0.16	0.88 ± 0.28
4th week, kg	1.44 ± 0.17	1.26 ± 0.24	1.28 ± 0.18	1.25 ± 0.14
Overall, kg	0.88 ± 0.18	0.84 ± 0.19	0.83 ± 0.14	0.80 ± 0.12
FE (feed/gain)[z]				
1st week, kg	1.59 ± 1.11[ab]	1.80 ± 0.17[a]	1.48 ± 0.44[ab]	1.38 ± 0.21[b]
2nd week, kg	2.14 ± 0.56	1.88 ± 0.24	1.97 ± 0.24	1.80 ± 0.42
3rd week, kg	2.28 ± 0.12	2.07 ± 0.39	1.93 ± 0.35	1.80 ± 0.25
4th week, kg	2.36 ± 0.29	2.07 ± 0.21	2.16 ± 0.16	1.79 ± 0.26
Overall, kg	2.09 ± 0.29[a]	1.96 ± 0.09[ab]	1.88 ± 0.08[ab]	1.69 ± 0.20[b]

[*] Mean ± SD.

[a, b] Means in the same row with different superscripts differ ($P < 0.05$).

[x, y, z] ADG: average daily gain, ADFI: average daily feed intake and FE: feed efficiency.

在血液細胞激素濃度方面，在離乳時，各處理組仔豬的 TNF-α、IL-1β、IL-6、IL-8 及 IL-10 濃度沒有顯著差異。但是在試驗結束日時，餵飼添加 0.1% 之狼尾草多醣萃取物比對照組，在發炎因子 IL-1β、IL-6 及 IL-8 濃度均顯著降低 (表 4)；餵飼添加 0.1% 之苜蓿多醣萃取比對照組，在發炎因子 IL-1β 與 IL-6 濃度顯著較低；餵飼添加 0.1% 之麩皮多醣萃取物比對照組，在發炎因子 IL-1β 濃度顯著較低。但是在發炎因子 TNF-α 濃度在 4 飼糧組間沒有顯著差異，而 IL-10 濃度，在 4 組均低於檢測極限。由此現象顯示，餵飼離乳仔豬不同來源植物多醣萃取物，具有抑制不同發炎因子的作用。相關的文獻亦有類似的結果 (Ewaschuk *et al.*, 2012; Cornick *et al.*, 2015;

Lee *et al.*, 2017)。因此，餵飼離乳仔豬添加 0.1% 狼尾草、苜蓿及麩皮之多醣萃取物飼糧，具有降低離乳仔豬發炎因子的作用，尤其是添加狼尾草多醣萃取物效果最佳。

VI. 飼糧添加 0.1% 植物多醣萃取物對離乳仔豬糞便菌相之影響

在離乳日，仔豬糞便中之乳酸菌、大腸桿菌與其他大腸桿菌群、其他腸內菌等菌數，在 4 處理組間沒有顯著差異 (表 5)。在離乳後第 15 天時，餵飼添加 0.1% 之狼尾草多醣萃取物比餵飼對照組飼糧，仔豬糞便中之乳酸菌數顯著較高，且大腸桿菌數顯著較低 (表 5)，但是在對照組、添加 0.1% 之麩皮或苜蓿多醣萃取物 3 組間，仔豬糞便中之乳酸菌、其他腸內菌、大腸桿菌與其他大腸桿菌群等菌數均沒有顯著差異，此現象可能因狼尾草多醣萃取物較有利於腸道乳酸菌菌群的生長，而使糞便中乳酸菌數增加。在試驗結束日時，餵飼添加 0.1% 之狼尾草與麩皮多醣萃取物比較對照組，仔豬糞便中之大腸桿菌數顯著較低，而苜蓿多醣萃取物組雖然沒有顯著比對照組降低大腸桿菌數，但是仍有降低 30.7% 大腸桿菌數的效果 (表 5)，此現象可能亦因狼尾草多醣萃取物較有利於腸道微生物作用，產生揮發性脂肪酸降低腸道中大腸桿菌數量所致 (Biagi *et al.*, 2006; Jha and Berrocoso, 2015; Mach *et al.*, 2015)。由上述結果顯示，餵飼添加 0.1% 之狼尾草多醣萃取物飼糧，具有抑制離乳仔豬腸道大腸桿菌菌數的作用；同時在離乳後第 15 天時，餵飼添加 0.1% 之狼尾草多醣萃取物，具有顯著提高離乳仔豬的腸道乳酸菌數的作用，隨之改變仔豬糞便之大腸桿菌與乳酸菌數。

表 4.　飼糧中添加 0.1% 不同植物多醣對 LYD 離乳仔豬免疫球蛋白與細胞激素之影響

Table 4.　Effect of adding 0.1% different kind of plant polysaccharide on the concentration of blood immunoglobulin and cytokines of LYD weaned pigs

Items Time	Control (C)	C+ 0.1% wheat bran polysaccharide	C+ 0.1% alfalfa meal polysaccharide	C+ 0.1% taishu No. 3 polysaccharide
No.	8	8	8	8
Day 1				
IgG, × 10^5 ng/mL	4.39 ± 1.38	3.94 ± 1.52	4.08 ± 2.32	4.44 ± 2.14
IgA, × 10^5 ng/mL	8.58 ± 3.89	7.95 ± 3.68	11.11 ± 5.53	8.80 ± 2.99
IgM, × 10^5 ng/mL	0.96 ± 0.17	0.95 ± 0.30	1.37 ± 0.46	1.46 ± 0.50
TNF-α, pg/mL	147.1 ± 42.9	118.0 ± 32.7	100.2 ± 22.6	147.7 ± 35.3
IL-1β, pg/mL	456.2 ± 54.6	369.8 ± 31.3	524.3 ± 71.9	420.5 ± 59.2
IL-6, pg/mL	24.9 ± 5.7	32.6 ± 8.3	36.6 ± 4.8	24.9 ± 2.7
IL-8, pg/mL$^{\Psi}$	46.4 ± 13.9	< 31.20	< 31.20	< 31.20
IL-10, pg/mL$^{\gamma}$	< 7.8	< 7.8	< 7.8	< 7.8
Day 28				
IgG, × 10^5 ng/mL	68.87 ± 9.86	75.09 ± 11.37	72.91 ± 10.59	84.87 ± 12.51
IgA, × 10^5 ng/mL	56.23 ± 7.37	61.87 ± 7.79	61.70 ± 8.04	70.45 ± 9.49
IgM, × 10^5 ng/mL	23.27 ± 9.73	20.47 ± 6.80	21.87 ± 5.86	24.45 ± 7.12
TNF-α, pg/mL	199.8 ± 52.2	138.1 ± 45.8	163.8 ± 58.7	100.9 ± 28.5
IL-1β, pg/mL	134.2 ± 34.3^{a}	29.6 ± 18.3^{b}	30.2 ± 9.2^{b}	26.8 ± 2.4^{b}
IL-6, pg/mL	122.5 ± 22.2^{a}	61.4 ± 21.7^{ab}	44.7 ± 5.1^{b}	43.4 ± 4.7^{b}
IL-8, pg/mL$^{\Psi}$	110.3 ± 36.2^{a}	50.5 ± 17.0^{ab}	55.7 ± 14.7^{ab}	38.7 ± 6.7^{b}
IL-10, pg/mL$^{\gamma}$	< 7.8	< 7.8	< 7.8	< 7.8

* Mean ± SD.

$^{\Psi, \Gamma}$ Detection limit of IL-8 and IL-10 are below 31.20 and 7.8 pg/mL, respectively.

$^{a, b}$ Means in the same row with different superscripts differ (P < 0.05).

表 5. 飼糧中添加 0.1% 不同植物多醣對 LYD 離乳仔豬糞便菌相之影響

Table 5. Effect of adding 0.1% different kind of plant polysaccharide on fecal microflora of LYD weaned pigs

Items / Time	Control (C)	C+ 0.1% wheat bran polysaccharide	C+ 0.1% alfalfa meal polysaccharide	C+ 0.1% taishu No. 3 polysaccharide
No.	8	8	8	8
Day 1				
Lactobacillus, × 10^8 cfu/g	53.8 ± 3.7*	59.1 ± 1.3	65.2 ± 1.2	77.8 ± 8.4
Other enterobacter, × 10^5 cfu/g	122.0 ± 1.4	153.0 ± 27.9	151.0 ± 20.7	126.5 ± 4.9
E. coli, × 10^5 cfu/g	132.0 ± 28.2	216.5 ± 18.1	243.5 ± 29.1	127.5 ± 48.7
Other Coliforms, × 10^5 cfu/g	15.1 ± 6.9	12.5 ± 2.1	21.5 ± 8.9	19.0 ± 9.8
Day 15				
Lactobacillus, × 10^8 cfu/g	45.2 ± 4.7^b	54.9 ± 4.9^{ab}	52.6 ± 3.7^{ab}	65.1 ± 4.2^a
Other enterobacter, × 10^5 cfu/g	107.1 ± 35.4	171.5 ± 3.5	191.0 ± 0.5	175.7 ± 19.5
E. coli, × 10^5 cfu/g	358.1 ± 24.2^a	196.5 ± 5.1^{ab}	235.5 ± 3.4^{ab}	122.4 ± 10.6^b
Other Coliforms, × 10^5 cfu/g	3.8 ± 0.3	1.4 ± 0.7	1.5 ± 0.5	1.1 ± 0.1
Day 28				
Lactobacillus, × 10^8 cfu/g	42.2 ± 8.0	51.8 ± 3.9	50.5 ± 1.9	62.5. ± 2.7
Other enterobacter, × 10^5 cfu/g	12.0 ± 1.8	5.5 ± 0.7	8.0 ± 5.2	6.0 ± 2.8
E. coli, × 10^5 cfu/g	354.7 ± 33.9^a	182.3 ± 22.7^b	245.7 ± 87.2^{ab}	119.3 ± 45.7^b
Other Coliforms, × 10^5 cfu/g	8.6 ± 0.1	1.3 ± 0.5	4.3 ± 0.6	1.6 ± 0.5

* Mean ± SD.

a, b Means in the same row with different superscripts differ ($P < 0.05$).

結　論

在離乳後 4 週內，餵飼添加 0.1% 狼尾草多醣萃取物，仔豬的飼料效率顯著較佳；在離乳後第 4 週時，餵飼添加 0.1% 狼尾草多醣萃取物比添加 0.1% 苜蓿多醣萃取物飼糧組，仔豬的日增重顯著較高。餵飼離乳仔豬添加 0.1% 狼尾草、苜蓿與麩皮之多醣萃取物組，分別具有抑制發炎因子 IL-1β、IL-6 及 IL-8、IL-6 與 IL-8 以及 IL-1β 的作用。在仔豬腸道菌相，餵飼添加 0.1% 之狼尾草多醣萃取物飼糧，抑制仔豬腸道大腸桿菌菌數，同時在離乳後第 15 天時，亦比餵飼未添加植物多醣飼糧具有增加仔豬腸道乳酸菌數的作用。因此，建議可於離乳仔豬飼糧添加 0.1% 狼尾草多醣萃取物，改善離乳後第 4 週仔豬的日增重、飼料效率、增加腸道乳酸菌數以及降低發炎因子濃度等作用。

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The effect of plant polysaccharide extracts on the growth performance, the fecal microflora, and the concentration of inflammatory factor of postweaning pigs [1]

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Abstract

The purpose of this study was to evaluate the effects on the growth performance, intestinal microflora and anti-inflammation of postweaning piglets by adding 0.1% polysaccharide extracts respectively to the wheat bran, alfalfa meal or *Pennisetum purpureum* (Taishu No. 3). Experimental animals comprised 4-week-old LYD crossbred weaning pigs. A total of 32 piglets (male and female in half) were allocated into 4 groups by weight and gender and housed in 16 nursery pens; and each pen raised 1 male and 1 female for a 4-week experiment period. Basal diet, containing 18% crude protein and 3,500 kcal/kg digestible energy, was blended with 0.1% of the wheat bran, alfalfa meal or Taishu No. 3 polysaccharide extracts as experimental group. Polysaccharide extracts in plant sources were collected through hot water extraction. The polysaccharide content by dry matter content of polysaccharide extract from alfalfa meal was 9.0%, followed by wheat bran 11.6% and Taishu No. 3 17.9%. During the first week of experiment, pigs diet added with 0.1% Taishu No. 3 polysaccharide extract showed a significantly ($P < 0.05$) efficient feed conversion rate than adding 0.1% alfalfa meal polysaccharide extract. During the fourth week of experiment, the feeding of 0.1% Taishu No. 3 polysaccharide extract also showed a significantly higher daily gain than adding 0.1% wheat bran polysaccharide extract. Weaning piglets fed 0.1% polysaccharide extracts from Taishu No. 3, alfalfa meal and wheat bran in diets had three kinds of anti-inflammation factor respectively (IL-1β, IL-6 and IL-8), two kinds of anti-inflammatory factor (IL-6 and IL-8), and one kind of anti-inflammatory factor (IL-1β). In the gut microflora of postweaning piglet, pigs fed 0.1% polysaccharide extract from Taishu No. 3, significantly ($P < 0.05$) inhibited the number of piglets intestinal *E. coli* better than adding polysaccharide extract from alfalfa meal. On the 15th day, pigs fed 0.1% Taishu No. 3 polysaccharide extract also showed a higher amount in intestinal lactobacillus than control group. In conclusion, the results indicated that adding 0.1% Taishu No. 3 polysaccharide extract into postweaning pigs diet improves the average daily gain and feed conversion rate in the fourth week after weaning. It also increases the number of gut lactobacillus and reduce the concentration of inflammation factor.

Key words: Plant polysaccharide, Extract, Gut microflora.

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飼料中添加丁酸鈉與檸檬酸對離乳仔豬生長性能的影響 (1)

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摘　要

本試驗旨在探討飼糧中添加丁酸鈉與檸檬酸對離乳仔豬生長性能的影響。試驗採用 4 週齡離乳仔豬 48 頭 (藍瑞斯 × 杜洛克)，依體重及性別逢機分為 4 組，各組有機酸添加量分別為 0.00% 對照組 (A)、0.10% 丁酸鈉組 (B)、0.70% 檸檬酸組 (C) 及 0.05% 丁酸鈉 + 0.35% 檸檬酸組 (D)，每處理 3 重複 (欄)，每欄 4 頭 (公、母各半)。飼料中粗蛋白質與代謝能含量，分別為 18.6% 與 3,212 kcal/kg。試驗期間自離乳日至離乳後 4 週 (5 － 8 週齡)，每週測定體重及採食量，結果顯示，A、B、C 及 D 組豬隻之平均隻日飼料採食量分別為 0.692、0.699、0.623 及 0.783 kg，D 組的採食量最高，並顯著高於 C 組 ($P < 0.05$)，但與對照組 (A 組) 無顯著差異。在增重方面，各組有相似的現象，亦以 D 組最高 (0.417 kg/day/head)，並有高於 C 組 (0.321 kg/day/head) 的趨勢 ($P = 0.10$)，與對照組無顯著差異。試驗中期，A 組仔豬血清 IgA 濃度 694.4 mg/dL，顯著 ($P < 0.05$) 高於其它 3 組，但試驗中及後期各組 IgG 濃度均無顯著差異。綜上所述，離乳仔豬給飼同時添加丁酸鈉及檸檬酸飼料，其採食量較單獨添加檸檬酸者高，且在增重上亦有較佳的趨勢。

關鍵詞：離乳仔豬、有機酸、生長性能。

緒　言

仔豬離乳時的緊迫，可能增加疾病發病率，在離乳過程中，仔豬與母豬分離，仔豬混群和社會序位重排，採食量下降甚至未採食，這些壓力造成仔豬的緊迫 (Brooks *et al.*, 2001)，可能造成仔豬的生長表現下降。雖然飼料中添加抗生素可降低離乳仔豬發生疾病的機率，但抗生素可能造成細菌產生抗藥性 (Smith *et al.*, 2010)，在未來抗生素的使用將受到更大的限制。另一方面，為了減輕緊迫壓力對仔豬的負面影響，可藉由添加有機酸對抗離乳仔豬緊迫，以改善仔豬的生長表現 (Lallés *et al.*, 2004)。

仔豬哺乳階段，胃腸道中酸的來源，主要由胃部泌酸細胞分泌，部分則需要依賴母豬乳汁中的乳糖，經由乳酸菌發酵成乳酸，幫助降低胃部的 pH 值；不過當乳酸量過多時，亦會抑制胃部酸的分泌量 (Schulman, 1973; Gilliland *et al.*, 1975)。仔豬離乳後，受到離乳緊迫造成胃部泌酸能力下降 (Kenworthy and Crabb, 1963)，加上飼料中蛋白質 (如大豆粕或魚粉等) 具有緩衝胃酸與減緩胃中 pH 值下降的能力，導致仔豬消化能力下降與大腸桿菌數增加；而未被完全消化的營養分移動至後腸，經微生物發酵分解，容易引起下痢，嚴重者則影響仔豬離乳初期的生長與免疫力 (Pluske, 2013)。

有機酸具有抑菌和殺菌的作用，當有機酸於解離前以親脂性型態存在，具有穿透革蘭氏陰性菌細胞膜的能力，當有機酸進入細菌細胞內解離成氫離子和羧基陰離子，氫離子可降低細菌細胞內 pH 值，而羧基陰離子則具有抑制細菌 DNA 和蛋白質合成的作用 (Russel and Diez-Gonzales, 1998; Stratford and Anslow, 1998)。此時細菌為維持細胞內 pH 值的中性平衡，消耗能量以 H+-ATPase 幫浦 (The proton-pump ATPase) 將氫離子經由細胞膜排出細胞外，使得細胞質 pH 值維持於中性狀態。因此，經過長時間有機酸的作用，可使細菌因能量耗盡而死亡 (Roe *et al.*, 1998)。酸化劑的殺菌效果取決於有機酸的解離程度，當有機酸在動物消化道中解離程度越低，其殺菌效果越強 (Giannattasio *et al.*, 2013)。一般來說，無機酸 (如磷酸) 在動物消化道中的解離程度甚高，因此其殺菌作用較差；反之，有機酸在消化道中解離程度較低，待有機酸進入細菌細胞內才解離成氫離子和羧基陰離子，則其殺菌效果則較強。

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檸檬酸為離乳仔豬飼糧常用的有機酸之一，一般仔豬飼糧中常見的建議添加用量為 0.7 － 1%。一般而言，檸檬酸具有降低仔豬胃腸道的 pH 值、活化消化酶、促進有益菌的繁殖、防止仔豬下痢、抑制大腸桿菌與葡萄球菌生長等效果 (Falkowski and Aherne, 1984)。Kil *et al.* (2011) 認為離乳仔豬使用檸檬酸的試驗結果差異很大。Radecki *et al.* (1988) 的研究顯示，添加 1.5% 檸檬酸對仔豬採食量與增重有抑制的結果。

另一方面，丁酸鈉在動物腸道中，雖可以被解離為丁酸鹽與鈉離子，仍有部分可以通過小腸，直接進入盲腸和結腸後，再解離為氫離子與丁酸根陰離子，除可以抑制有害菌 (如大腸桿菌) 與增加腸道有益菌 (如乳酸桿菌) 的數量，維持畜禽腸道內微生物菌叢平衡 (Galfi and Bokori, 1990)，同時丁酸可作為能量來源 (Mathew *et al.*, 1996)。丁酸鈉亦具有促進離乳仔豬免疫力的作用，提升仔豬血液中的 IgG 和 IgA 濃度，強化仔豬的免疫力 (Boeker *et al.*, 1999)。在豬隻飼料建議用量範圍為 0.05 － 0.4%，一般以 0.1% 為最常推薦用量 (Piva *et al.*, 2002a)。

檸檬酸與丁酸常被添加於飼料中，作為仔豬的保健劑，其試驗結果各有論述，在使用上亦常有不同看法。為比較兩者在離乳仔豬使用上的差異，本試驗探討檸檬酸、丁酸鈉與兩者混合使用添加於飼料中，對離乳仔豬生長性能的影響，供離乳仔豬飼糧中使用有機酸之參考。

材料與方法

本試驗於行政院農業委員會畜產試驗所 (以下稱畜試所) 產業組的試驗豬舍進行，試驗動物之使用、飼養管理及試驗內容，經畜產試驗所實驗動物管理小組以畜試動字第 108040 號申請核准在案。

I. 動物試驗

以 4 週齡二品種雜交離乳仔豬 (L × D) 48 頭，逢機分為 4 組，每組 3 重複，共 12 欄，每欄 4 頭 (公母各半)，每欄面積 2.55 m^2。仔豬飼養於傳統開放式高床保育豬舍。飼料中粗蛋白質及代謝能含量，分別為 18.6% 及 3,212 kcal/kg (表 1)。對照組 (A 組) 飼料中未添加有機酸劑，處理組 B 與 C 組參照其推薦用量分別於飼料中添加 0.10% 丁酸鈉 (Sodium butyrate, No. 26319, Acros Organics, Belgium；B 組) 與 0.70% 檸檬酸 (Citric acid monohydrate，產品登錄號：TFAB1C009247007，中國；C 組)，D 組則同時添加 0.05% 丁酸鈉 + 0.35% 檸檬酸 (兩者均為推薦量的一半)。試驗期間為離乳日至離乳後 4 週 (5 － 8 週齡)。離乳後懸掛 175 W 保溫燈，為期 1 週，試驗期間採任食，並供應飲水，仔豬 7 週齡時，注射假性狂犬病基因缺損不活化疫苗 (PR，第 1 次) 與豬放線桿菌不活化菌苗 (1、5 型) (AP，第 1 次)。每週將仔豬置於電子磅秤上，測定仔豬體重，同時測定剩餘飼料以計算採食量，供分析仔豬生長性能；試驗中 (6 週齡) 與後期 (8 週齡)，於上午 10 時，以人工保定，採集頸靜脈血液 5 mL，經 3,000 rpm/15 min (FCF = 1,940 x *g*) 離心後，取血清以酵素免疫分析儀 (EZ Read 400, Biochrom, Thermo Fisher Scientific Inc., Sweden) 檢測免疫球蛋白 A (IgA) 及 G (IgG) 的濃度。

II. 統計分析

試驗採完全逢機設計 (Completely randomized design, CRD)，試驗資料使用 SAS 統計套裝軟體 (statistical analysis system. SAS, 2002)，利用一般線性模式程序 (General linear model procedure) 進行變方分析，若達 $P < 0.05$ 顯著差異時，再以 Lsmeans 比較處理組間之差異顯著性。

結果與討論

I. 離乳仔豬生長性能

試驗期間離乳仔豬的生長性能如表 2。A、B、C 與 D 組之全期平均飼料採食量分別為 0.69、0.70、0.62 與 0.78 kg/day/head，以同時添加 0.05% 丁酸鈉及 0.35% 檸檬酸 (D 組) 顯著高於 C 組 ($P < 0.05$)，但未顯著高於對照組。C 組採食量為各組中最低，但未顯著低於對照組。仔豬在第 5 與 7 週齡的採食量有相同的現象，D 組顯著高於 C 組 ($P < 0.05$)，但未顯著高於對照組。顯示飼料中添加 0.70% 檸檬酸或只添加 0.10% 丁酸鈉，對仔豬採食量無顯著提升的效果，甚至單獨添加 0.70% 檸檬酸，似乎有抑制仔豬採食量的現象。

哺乳仔豬胃中酸的主要功能為降低胃中的 pH 值，其來源為胃部泌酸細胞分泌及母豬乳汁中乳糖發酵成乳酸 (Schulman, 1973; Gilliland *et al.*, 1975)。離乳緊迫造成仔豬胃部泌酸能力降低 (Kenworthy and Crabb, 1963)，加上飼料中蛋白質的緩衝胃酸作用，延長胃液中 pH 值下降的時間，導致仔豬對飼料消化能力下降，而未被消化的飼料常引起仔豬的下痢，並降低仔豬離乳初期的生長表現 (Pluske, 2013)。本試驗以同時添加檸檬酸與丁酸鈉採食

量最高，雖未顯著高於對照組，但顯著高於單獨添加檸檬酸組，推測同時添加此兩種有機酸對促進仔豬消化能力及提升採食量的效果，較單獨添加檸檬酸者佳。

表 1.　仔豬基礎飼糧配方組成

Table 1.　The compositions of the basal diet for the piglets

Item	%
Ingredients	
Yellow corn meal	64.72
Soybean meal	22.00
Fish meal	5.00
Skimmed milk powder	2.00
Whey powder	2.00
Soybean oil	1.00
Dicalcium phosphate	1.50
Limestone, pulverized	1.00
Salt	0.40
Choline chloride, 50%	0.08
DL-Lysine・HCl, 98.5%	0.05
Premix-Vit[1]	0.15
Premix-Min[2]	0.10
Total	100.00
Calculated values	
Crude Protein, %	18.61
ME, kcal/kg	3,212
Calcium, %	0.99
Total phosphorus, %	0.72
Available phosphorus, %	0.56

[1] Vitamin premix provided per kilogram of diet: vitamin A, 9,000 IU; vitamin D_3, 600 IU; vitamin E, 60 IU; vitamin K, 3 mg; vitamin B_1, 3 mg; vitamin B_2, 9 mg; vitamin B_6, 4.5 mg; vitamin B_{12}, 0.045 mg; nicotinic acid, 45 mg; calcium pantothenate, 45 mg; folic acid, 0.9 mg and biotin, 0.3 mg.

[2] Mineral premix provided per kilogram of diet: Cu, 5 mg; Mn, 6 mg; Co, 0.35 mg; Zn, 40 mg; I, 0.2 mg; Se 0.1 mg and Fe, 80 mg.

A、B、C 與 D 組全期平均增重分別為 0.358、0.361、0.321 與 0.417 kg/day/head，各處理組與對照組間均無顯著差異，但以處理 D 組最高為 0.417 kg/day/head，且有較 C 組高的趨勢 ($P = 0.10$)。5 － 7 週齡各週的增重亦均以 D 組為最高，C 組最低，且 6 週齡時 D 組的增重為 0.376 kg/head/day 顯著 ($P < 0.05$) 高於 C 組的 0.253 kg/day/head。

A、B、C 與 D 組全期各組平均飼料效率 (Body weight gain/feed intake) 分別為 0.512、0.515、0.515 與 0.533，各組間無顯著差異。6 週齡時 D 組的飼料效率為 0.645 顯著優於 C 組的 0.541 及 A 組的 0.504 ($P < 0.05$)。

綜上所述，本試驗添加 0.10% 丁酸鈉、0.70% 檸檬酸及 0.05% 丁酸鈉 + 0.35% 檸檬酸未得到顯著提高採食量與增重的結果，對飼料效率亦無顯著影響，但同時添加丁酸鈉及檸檬酸者，其採食量較單獨添加檸檬酸者高，且在增重上亦有較佳的趨勢。

Lu *et al.* (2008) 指出離乳仔豬飼料中添加 0.10% 丁酸鈉，可提高仔豬採食量與增重及改善飼料效率，但飼料中添加 0.05% 丁酸鈉則沒有改善採食量、增重與飼料效率的效果。Piva *et al.* (2002b) 仔豬離乳後第 1 － 2 週，飼糧中補充丁酸鈉可增加仔豬 16% 採食量，同時提升每日增重 20%。Biagi *et al.* (2007) 則指稱離乳仔豬飼料中添加丁酸鈉，對仔豬採食量與增重無顯著影響。Weber and Kerr (2008) 之研究顯示，離乳仔豬飼料中添加 0.00、

0.05、0.10、0.20 及 0.40% 丁酸鈉對仔豬的生長性能無改善現象，相反的，隨著丁酸鈉添加量的提高有抑制的趨勢。

表 2. 飼糧中添加不同有機酸對離乳仔豬 (5 － 8 週齡) 生長性表現的影響

Table 2. Effect of different organic acids on growth performances of the weaned piglets (5-8th-wk-old)

Group Organic acid added, %	A[1] (0.00%)	B (SB 0.10%)	C (CA 0.70%)	D (SB 0.05% + CA 0.35%)
Age	Feed intake (kg/day/piglet)			
5th-wk	0.324 ± 0.096[ab*]	0.297 ± 0.037[ab]	0.280 ± 0.048[b]	0.397 ± 0.040[a]
6th-wk	0.582 ± 0.133	0.612 ± 0.033	0.469 ± 0.064	0.576 ± 0.111
7th-wk	0.861 ± 0.143[ab]	0.834 ± 0.048[ab]	0.766 ± 0.202[b]	1.054 ± 0.022[a]
8th-wk	1.002 ± 0.133	1.054 ± 0.047	0.978 ± 0.086	1.106 ± 0.042
Whole period	0.692 ± 0.121[ab]	0.699 ± 0.040[ab]	0.623 ± 0.082[b]	0.783 ± 0.028[a]
	Body weight gain (kg/day/piglet)			
5th-wk	0.181 ± 0.085	0.150 ± 0.050	0.140 ± 0.064	0.276 ± 0.183
6th-wk	0.294 ± 0.070[b]	0.353 ± 0.032[ab]	0.253 ± 0.030[b]	0.376 ± 0.043[a]
7th-wk	0.456 ± 0.016	0.460 ± 0.042	0.431 ± 0.109	0.534 ± 0.034
8th-wk	0.499 ± 0.088	0.479 ± 0.048	0.459 ± 0.057	0.483 ± 0.042
Whole period	0.358 ± 0.061	0.361 ± 0.042	0.321 ± 0.064	0.417 ± 0.038
	Feed efficiency (Body weight gain/Feed intake)			
5th-wk	0.560 ± 0.103	0.504 ± 0.123	0.499 ± 0.142	0.695 ± 0.150
6th-wk	0.504 ± 0.045[b]	0.576 ± 0.023[ab]	0.541 ± 0.040[b]	0.654 ± 0.060[a]
7th-wk	0.530 ± 0.090	0.552 ± 0.044	0.564 ± 0.070	0.506 ± 0.022
8th-wk	0.498 ± 0.027	0.454 ± 0.027	0.470 ± 0.054	0.436 ± 0.040
Whole period	0.512 ± 0.018	0.515 ± 0.038	0.515 ± 0.033	0.533 ± 0.043

[*] Mean ± SD.

[a, b] Means in the same row with different superscripts differ ($P < 0.05$).

[1] A group: control group, non-adding organic acid; B group: adding sodium butyrate (SB) 0.10%; C group: adding citric acid monohydrate (CA) 0.70%; D group: adding sodium butyrate 0.05% and citric acid monohydrate 0.35%.

本試驗添加丁酸鈉組採食量 0.699 kg/d 與對照組 0.692 kg/d 相近，添加檸檬酸組 (0.623 kg/d) 則降低採食量 10.0%，同時添加丁酸鈉及檸檬酸組 (0.783 kg/d) 則提升採食量 13.2%，在增重方面亦有類似的現象，本試驗的結果較偏向支持添加丁酸鈉提高仔豬採食量與增重的論點。

一般而言，檸檬酸可以提高離乳仔豬增重及改善飼料效率，在試驗的前兩週，有提升增重和飼料效率的效果，但只有少數試驗結果顯示，對增重或飼料效率有顯著的改善。Kil *et al.* (2011) 認為飼料中添加檸檬酸通常會降低仔豬採食量，且離乳仔豬使用檸檬酸，在不同試驗常得到不同的結果。Radecki *et al.* (1988) 使用 1.5% 的檸檬酸對仔豬採食量與增重則有明顯抑制的結果。

本試驗使用 0.70% 檸檬酸對仔豬採食量與增重無顯著改善效果，且為各組中最低，本試驗結果較偏向支持單獨添加檸檬酸降低仔豬採食量與增重的論點。

II. 血清中 IgA 及 IgG 濃度

本試驗中期 (6 週齡)，A 組仔豬血清中 IgA 濃度為 694.4 mg/dL (表 3)，顯著高於各處理組 ($P < 0.05$)，顯示離乳仔豬給添加有機酸飼糧 2 週後，血清中 IgA 有較低的現象。IgA 主要分布於粘膜，包括鼻、咽、氣管、腸和膀胱粘膜表面等，為粘膜表面分泌物中的主要抗體，是重要的第一道防線 (Woof and Kerr, 2006)。一般而言，有機酸具有降低仔豬胃腸道的 pH 值、抑制大腸桿菌與葡萄球菌生長等效果 (Falkowski and Aherne, 1984)。推測可能由於有機酸抑制仔豬腸道中大腸桿菌與葡萄球菌生長，而降低處理組仔豬 IgA 的反應，以致血清中 IgA 濃度下降。另一方面試驗中與後期，各組血清中 IgG 濃度均無顯著差異。

表 3.　給飼有機酸後不同階段仔豬血清中 IgA 與 IgG 濃度

Table 3.　The concentrations of serum IgA and IgG of the piglets at different ages after feeding organic acid

Group	6th WK of age (N = 12)	12th WK of age (N = 12)
	IgA (mg/dL)	
A1	694.4 ± 23.0[a*]	429.1 ± 86.2
B	604.9 ± 54.2[b]	385.8 ± 20.3
C	586.3 ± 37.6[b]	428.9 ± 86.8
D	590.6 ± 19.1[b]	397.2 ± 89.7
	IgG (mg/dL)	
A	453.7 ± 21.4	162.7 ± 22.9
B	368.7 ± 125.5	163.7 ± 31.0
C	432.8 ± 25.9	183.0 ± 25.1
D	409.0 ± 7.8	179.4 ± 17.8

[*] Mean ± SD.

[a, b] Means in the same column with different superscripts differ significantly ($P < 0.05$).

[1] A, B, C and D the same as table 2.

結　論

飼料中添加 0.10% 丁酸鈉或 0.70% 檸檬酸或同時添加 0.05% 丁酸鈉及 0.35% 檸檬酸，對仔豬的採食量及增重無顯著效果，飼料中同時添加丁酸鈉或檸檬酸之採食量較單獨添加檸檬酸者高，且在增重上有較佳的趨勢。

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Effects of adding sodium butyrate and citric acid in feed on growth performances of the weaned piglets [1]

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Abstract

The purpose of this study was to evaluate the effect of adding sodium butyrate and citric acid in the diet on the growth performances of weaned piglets. A total of 48 hd weaning piglets (Landrace × Duroc), 4 weeks of age, were randomly divided into 4 groups. The amount of organic acid added in the groups were 0.00% organic acid (A), 0.10% sodium butyrate (B), 0.70% citric acid (C) and 0.05% sodium butyrate plus 0.35% citric acid (D), respectively. They were 3 pens in each group, and 4 piglets (half comprised of male and female) per pen. The crude protein and metabolizable energy content of the diet were 18.6% and 3,212 kcal/kg, respectively. During the 4 weeks study period (5 - 8 weeks of age), the body weight and feed intake of the piglets were measured weekly. The results showed that the average feed intake of A, B, C and D groups were 0.692, 0.699, 0.623, and 0.783 kg//day/head, respectively. The feed intake in group D was significantly ($P < 0.05$) higher than group C, but not significantly higher than the control group. The body weight gain was also the highest in group D (0.417 kg/day/head), and had a tendency higher than group C (0.321 kg/day/head) ($P = 0.10$), but nor significantly higher than the control group. At the 6th week of age, the IgA concentration in the serum of group A was 694.4 mg/dL, which was significantly higher than the other groups. There was no difference between the IgG concentration in each group at the 6th and 12th week of age. In conclusion, piglets fed with diet added with 0.05% sodium butyrate and 0.35% citric acid, had the feed intake higher than adding citric acid alone, which tended to show larger body weight gain.

Key words: Weaned piglet, Organic acid, Growth performance.

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墊料重複使用對白肉雞產能與墊料量之影響 (1)

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摘　要

本研究旨在評估墊料重複使用對白肉雞生產效能與墊料量之影響，試驗利用平飼白肉雞飼養場之飼養管理紀錄表，記錄每批入雛日期、雞舍入雛數、每日死亡數、飼料用量、出雞日期、出售隻數、出售總重及墊料重複使用飼養批次等資料，評估養雞場生產效能，並調查白肉雞以逐批飼養與重複飼養之墊料產量。結果顯示，墊料重複使用於白肉雞飼養 1 － 5 批次，平均出售日齡、出售體重、飼料換肉率 (Feed conversion ratio, FCR)、育成率及生產指數，分別介於 35.3 － 36.0 日、2.08 － 2.15 kg、1.48 － 1.50、95.5 － 97.6% 及 382 － 394 之間，批次間均無差異顯著性。各批次之雞隻死亡率皆以 1 週齡時高於 2、3、4、5 及 6 週齡 ($P < 0.05$)，且死亡率在批次與週齡間無顯著之交感效應。每隻雞產生之墊料重量隨著重複使用批次增加而有降低趨勢，逐批清理墊料者其平均重量為 1.08 kg/ 隻，而重複飼養 2、3、4 及 5 批次之平均墊料量則分別介於 0.78 － 0.63 kg/ 隻之間。綜上所示，平飼白肉雞場墊料重複使用 5 批次尚不影響養雞場之生產效能，且可降低墊料量，可作為養雞業者參考之飼養模式之一。

關鍵詞：白肉雞、雞糞墊料、重複使用、生產效能。

緒　言

家禽提供國人蛋白質來源，為國內重要產業之一，家禽分為雞、鴨、鵝等三大類，臺灣養雞產業分為蛋雞及肉雞產業，肉雞種類包括白色肉雞與有色肉雞，白色肉雞的生長快速，上市週齡約為 6 週內，上市體重平均為 1.9 － 2.1 kg；有色肉雞則需飼養 12 至 14 週，上市體重平均為 2.4 － 4.0 kg。白色肉雞生產在我國農業經濟占有一席重要地位，根據 2019 年行政院農業委員會農業統計年報資料顯示，107 年畜產產值占農業生產結構 (農產、林產、畜產、漁產) 百分比為 31.69%，其中白肉雞產值占畜產產值百分比為 4.08%，僅次於豬 13.38% 及有色肉雞 4.26%，顯見白色肉雞產業在畜產產值貢獻程度及重要性。

平飼肉雞飼養普遍於肉雞舍床面舖陳墊料 (Litter)，可兼顧動物福祉，並吸附飼養過程雞隻排泄物與飲水溢漏的水分等雙重目的 (Collett, 2012)。肉雞舍床面舖陳墊料一般以在地生產之農業廢棄資材為主，包括木屑、稻稈、稻殼 (粗糠)、椰殼纖維或花生殼等，臺灣地區以稻殼舖陳最為廣泛。國內稻穀生產因產銷調節與配合休耕措施，間接導致稻殼供應有不足之虞，因此有研究利用切短後之稻稈、椰子殼粉碎後之纖維取代粗糠，作為墊料代替物 (劉等，2009；蘇等，2015)。Toghyani *et al.* (2010) 以無墊料、木屑、稻殼、廢紙及砂進行試驗，顯示 5 組不同墊料不影響飼料換肉率，但在稻殼組飼養的肉雞體重、飼料採食量明顯較低。Collins (1996) 指出，每 1,000 隻雞產生 1.1 － 1.4 公噸雞糞墊料 (1.1 － 1.4 kg/ 隻)，根據 2019 年行政院農業委員會農業統計年報資料顯示，臺灣地區白肉雞 107 年屠宰隻數為 226,540 千隻，以每隻雞飼養至出售產生 1.1 － 1.4 kg 雞糞墊料估算，白肉雞之雞糞墊料年產 249,194 － 317,156 公噸，因此每年家禽飼養過程所產生之事業廢棄物 (雞糞墊料) 數量龐大不可忽視。禽畜糞含未消化飼料、腸道細胞、微生物等含氮有機物 (Higgins *et al.*, 2008)。肉雞墊料為累積排泄物、羽毛、廢棄飼料與舖陳材質之混合物，含氮、磷、鉀及其他微量礦物質，非常適合提供為植物生長所需之營養源 (Bernhart *et al.*, 2010)。

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臺灣地區白肉雞場通常逐批清除雞糞墊料，再進行清潔、消毒後，舖陳新墊料，為下一批雞隻飼養作準備，鮮少墊料重複使用。肉雞場墊料管理通常分為單次使用 (Single use)、部分重複使用 (Partial re-use) 及重複使用 (Multi-use) 等三大類，單次使用為每一飼養批次 (Batch) 皆全部更換墊料；部分重複使用是批次飼養後，將育雛區的墊料灑佈在其他區域，育雛區更換新墊料；重複使用則是指在批次飼養後只移除結塊 (Cake) 的雞糞墊料 (Bolan *et al.*, 2010)。在美國商業肉雞場的墊料通常採取重複使用，重複使用的次數從二批次至數年 (Coufal *et al.*, 2006)，亦有每年於肉雞舍舖墊料 1 次，僅於每批肉雞出售後清除飼槽及飲水器下方之結塊墊料之飼養方式 (Wheeler *et al.*, 2006)。澳洲肉雞飼養約 70% 使用新墊料 (木屑或木片)，30% 為墊料重複使用 3 至 6 批次 (Chinivasagam *et al.*, 2012)；而巴西則使用同批墊料連續飼養肉雞 4 至 5 批次 (Xavier *et al.*, 2010)。

近年來社會關注施用雞糞造成環境之衝擊，所以妥善處理、減量或雞糞墊料重複使用，為養雞業者必須正視的問題。雞糞墊料逐批清除，相對墊料使用量亦增加，加上清除雞糞墊料必須投入人力。因此，本研究為收集平飼白肉雞飼養場於肉雞出售後，墊料重複使用，評估對白肉雞生產效能及雞糞墊料產量之影響。

材料與方法

I. 試驗雞舍

本研究之試驗雞舍位於雲林縣，雞舍為南北向，計有 4 棟水簾式平飼雞舍，圖 1 為雞舍示意圖，A 棟面積為 915 m^2 (長 61 m × 寬 15 m)，每批可飼養肉雞 12,500 隻 (飼養密度為 13.66 隻 /m^2)。B、D 棟分別為雙層式鋼構雞舍之上層、下層，雞舍面積均為 1,425 m^2 (長 95 m × 寬 15 m)，可飼養肉雞 22,000 隻 (飼養密度為 15.44 隻 /m^2)。C 棟面積為 894 m^2 (長 60 m × 寬 14.9 m)，可飼養肉雞 12,000 隻 (飼養密度為 13.42 隻 /m^2)。

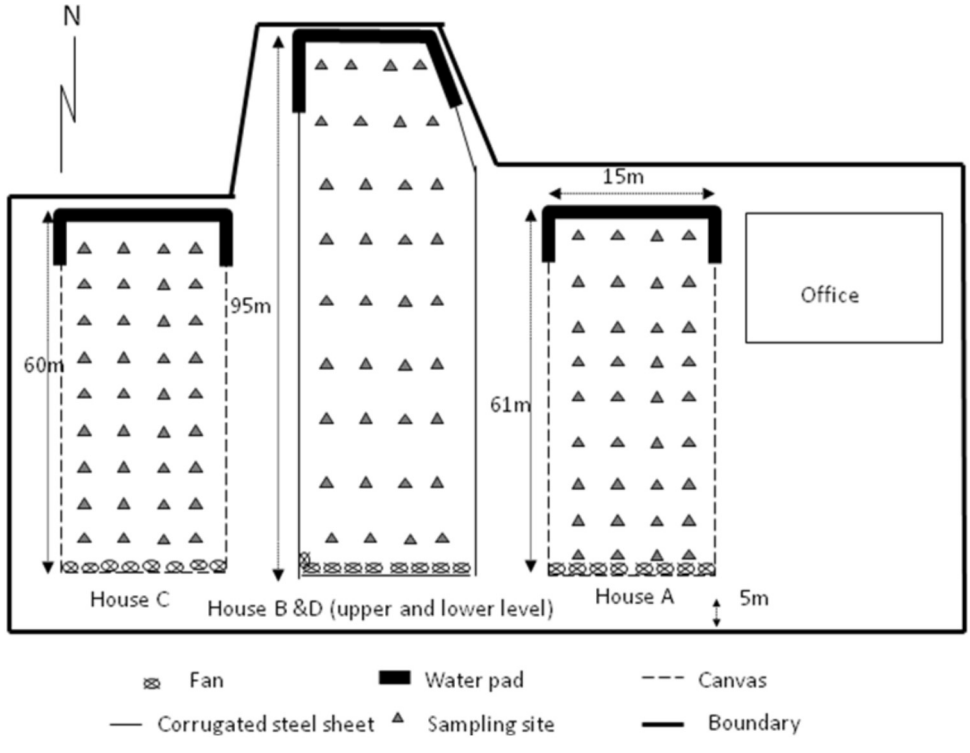

圖 1. 墊料重複使用試驗之雞舍示意圖及墊料厚度量測點。

Fig. 1. The schematic diagram of broiler buildings and litter sampling sites in this study.

II. 肉雞飼養管理

每批雞 (愛拔益加) 從入雛後開始以鐵皮圍籬圈養方式，利用柴油加熱機進行保溫，入雛日起第 4、5、7、10 日分別適度放寬圍籬以增加雛雞之活動空間。4 棟雞舍在育雛階段均採間歇性啟動風扇，使雞舍內通風達到有效換氣效果。肉雞 3 － 4 週齡、且雞舍內溫度達 29℃時啟動水簾降溫系統，並增加風扇運轉數目，雞舍內溫度達 31℃時除水簾降溫系統啟動外，雞舍安裝之風扇全數運轉，增加整棟雞舍換氣量。

飼料均購自商業飼料廠，分成三期料，每期料飼養天數視肉雞生長情況調整，第一、二及三期料分別提供

予 1 至 10 日齡、11 至 23 日齡及 24 日齡至出售雞隻。飼料粗蛋白質 (Crude protein, CP) 及可代謝能 (Metabolizable energy, ME) 含量，第一、二、三期料分別為 24% 及 3,200 kcal/kg、23% 及 3,260 kcal/kg、21% 及 3,300 kcal/kg。

III. 墊料管理方式

首批白肉雞入雛前清除舊墊料，進行清潔、清毒、淨空 4 － 7 天，再舖新稻殼 (約 2 － 3 cm)，飼養期間未再增添稻殼。每批肉雞出清後，以中耕機攪拌並粉碎雞糞墊料後，再噴灑市售生菌劑 (每萬隻使用 20 L 加水稀釋 50 倍) 於雞糞墊料上，啟動風扇並靜置 12 天。雞糞墊料重複使用飼養 2 － 5 批次肉雞後，清除雞糞墊料，再進行清潔、消毒、淨空 4 － 7 天，舖新稻殼為下一批入雛作準備。

IV. 肉雞生產效能評估

養雞場飼養管理紀錄表內容，包含記錄飼養批次、每批入雛日期、各棟雞舍入雛數 (含每百隻送 2 隻)、各棟每日死亡隻數、各棟各期飼料用量 (kg)、出雞日期、整場出售隻數、整場出售總重 (kg)。雞隻死亡率計算方式為第 1 週死亡率 (%) 為第 1 週死亡數 ÷ 實際入雛數 × 100，第 2 週死亡率為第 2 週死亡數 ÷ (實際入雛數減去第 1 週死亡數) × 100，依序計算得第 3、4、5、6 週死亡率。另以出售隻數 ÷ 入雛隻數 × 100，計算育成率 (%)；以出售總重 ÷ 出售總隻數，計算出售體重 (kg/ 隻)；並以飼料用量總重 ÷ 出售肉雞總重，計算飼料換肉率；計算生產指數 (Production index, PI) = 100 × [育成率 × 出售體重 (kg/ 隻)] ÷ (飼養天數 × 飼料換肉率)。

V. 墊料重複使用飼養肉雞之墊料厚度及墊料量資料收集

(i) 墊料重複使用期間之墊料厚度量測

雞舍床面墊料厚度量測期間為 102 年 11 月至 103 年 3 月，墊料重複使用飼養肉雞 3 批次，於每批次肉雞出清後，利用 30 cm 長之螺絲起子自每個量測點墊料床表面插至雞舍地面，再利用尺規量測螺絲起子插入深度並記錄。墊料厚度量測點為將每棟雞舍由水簾端至風扇端平均劃分 9 個縱斷面及由左側至右側平均劃分 4 個橫斷面 (圖 1)，即每棟雞舍區分為 36 個小區塊。

(ii) 墊料量資料收集

本研究於民國 101 至 105 年間進行墊料量資料收集，包含墊料重複使用飼養批數、起始月份、結束月份、雞舍別、總入雛數及墊料重 (如表 1)，飼養批次最高達 5 批次。墊料量資料收集以墊料重複使用飼養結束，將雞糞墊料裝袋，計算各棟雞舍雞糞墊料袋數，並利用經濟部標準檢驗局檢定合格之自家地磅磅秤 (購自東興衡器廠有限公司，臺灣桃園) 每棟雞舍逢機取 1 卡車秤重並計算裝載袋數，以載重 ÷ 裝載袋數計算每袋平均重量，再依每棟雞舍墊料袋數，計算每棟雞舍墊料量，加總成全場墊料量。每批次雞糞墊料重量 ÷ 重複飼養批次期間總入雛數，估算單位肉雞雞糞墊料量 (kg/ 隻)。

VI. 資料分析

試驗資料利用 SAS 套裝軟體 (SAS, 1988) 計算，包括各測定值之平均值及標準偏差，以一般線性模式程序 (General linear model procedure, GLM) 進行分析值之變方分析，並以鄧肯氏新多變域測定法 (Duncan's new multiple range test) 比較各試驗組之差異性。

結果與討論

I. 雞糞墊料重複使用於肉雞飼養之生產效能

墊料重複使用於平飼肉雞 (愛拔益加) 飼養之飼養批數、起始月份、結束月份、雞舍別、總入雛數如表 1 所示。101 年 5 月至 102 年 1 月重複飼養 4 批次，累計飼養數為 251,700 隻，使用雞舍為 A、B、C 及 D 棟；102 年 9 月至 102 年 10 月飼養 1 批次，飼養數為 19,500 隻，使用雞舍為 B 棟。表 1 為統計墊料重複使用之飼養期間為 101 年 5 月至 105 年 1 月及各批次之總入雛數介於 19,500 － 254,700 隻。

表 2 為墊料重複使用對肉雞飼養批次及週齡之死亡率影響。墊料重複使用 1、2、3、4 及 5 批次，分別有 25、33、28、16 及 5 筆整場週死亡率樣本數，雞隻平均死亡率分別為 0.60、0.50、0.72、0.62 及 0.39%，墊料重複使用 5 批次者顯著較飼養 3 批次者為低 ($P < 0.05$)，但墊料使用 5 批次僅 5 筆資料，遠比使用 1 － 4 批次為少，雖統計上有顯著差異，飼養者仍須注意飼養管理及疾病防範。肉雞重複飼養於雞糞墊料在 1、2、3、4、5 及 6 週齡期間，分別有 20、20、20、20 及 7 筆批次飼養之週死亡率樣本數，雞隻平均死亡率分別為 1.36、0.44、0.32、0.35、0.67 及 0.09%，平均死亡率皆以 1 週齡顯著高於 2、3、4、5 及 6 週齡 ($P < 0.05$)。

Xin *et al.* (1994) 指出，肉雞死亡率高峰發生於入雛後 3 － 4 日。Jones and Hagler (1983) 在肉雞舍舖新墊料 (木屑) 或墊料重複使用之研究發現，以此 2 種墊料型態飼養肉雞於第 1 週雞隻死亡率較高與本研究結果相似。社團法人中華民國養雞協會 (2019) 進行白肉雞雛雞品質調查專案 (第五版)，結果發現國內前十家種雞場肉雛雞在一週齡的平均損失率介於 0.95 － 1.83% 之間，顯示本研究的 1.36% 仍於正常範圍內。因本研究之肉雞平均出售日齡 35 － 36 日 (表 3)，第 6 週齡計算死亡數及死亡率僅 1 － 2 日，導致第 6 週齡之死亡數及死亡率偏低。以墊料重複使用飼養批次、週齡及批次 × 週齡對死亡率之影響進行統計分析，結果顯示墊料重複使用批次間之死亡率以飼養 3 批次顯著高於 5 批次 ($P < 0.05$)，雞隻不同週齡間之死亡率以飼養第 1 週齡顯著高於第 2 － 6 週齡 ($P < 0.05$)，且死亡率在批次與週齡間無顯著之交感效應，顯示墊料重複使用於肉雞飼養不影響其生產效能，故管理者在肉雞飼養期間，須特別注重入雛 1 週內雛雞飼養管理，藉以降低死亡率。

表 1.　墊料重複使用於白肉雞飼養之期間及批次

Table1.　The duration and the batches of the broilers feeding in litter reusing experiment

Reared batch[1]	Chick arrival	Market	House	Chicks no. (birds)	Litter weight (kg)	Litter wt.[2] (kg/bird)
4	May 2012	Jan. 2013	A, B, C, D	251,700	200,340	0.78
4	Jan. 2013	Aug. 2013	B	80,200	51,670	0.63
5	Jan. 2013	Oct. 2013	A, C, D	224,500	143,258	0.63
1	Sep. 2013	Oct. 2013	B	19,500	21,500	1.08
3	Nov. 2013	Mar. 2014	A, B, C, D	189,700	126,790	0.66
3	Apr. 2014	Sep. 2014	A, B, C, D	195,500	132,415	0.66
2	Sep. 2014	Dec. 2014	A, B, C, D	126,600	93,403	0.72
4	Aug. 2015	Jan. 2016	A, B, C, D	254,700	177,460	0.68

[1] Numbers of batches using the recycled litter.

[2] Litter wet weight after market / total numbers of chicks in the different batches.

表 2.　墊料重複使用批次與週齡對白肉雞死亡率之影響

Table 2.　The broilers mortality on the batches and the age of broiler using reused litter

Reared batch	n[1]	Mortality[2] (%)	Age (weeks)	n	Mortality (%)
1	25	0.60 ± 0.08^{ab}	1	20	1.36 ± 0.14^{a}
2	33	0.50 ± 0.07^{ab}	2	20	0.44 ± 0.06^{bc}
3	28	0.72 ± 0.13^{a}	3	20	0.32 ± 0.02^{cd}
4	16	0.62 ± 0.16^{ab}	4	20	0.35 ± 0.03^{cd}
5	5	0.39 ± 0.17^{b}	5	20	0.67 ± 0.09^{b}
			6	7	0.09 ± 0.03^{d}

Significance[3]	Mortality (%)
Reared batch	*
Age	***
Reared batch × Age	NS

[1] Sample numbers.

[2] Mean ± standard error; Means in the same column with different superscripts are significantly different ($P < 0.05$).

[*] $P < 0.05$; [***] $P < 0.001$; NS: Not significant.

表 3 為肉雞於墊料重複飼養之生產效能，統計飼養 1、2、3、4 及 5 批次，分別有 6、6、5、3 及 1 筆批次飼養紀錄，批次間之出售日齡、出售體重、飼料換肉率、育成率及生產指數，分別介於 35.3 － 36.0 日、2.08 － 2.15 kg、1.48 － 1.50、95.5 － 97.6% 及 382 － 394，各墊料重複使用批次間均無顯著差異，表示肉雞於雞糞墊料重複飼養 5 批次以下時，出售日齡、出售體重、飼料換肉率、育成率及及生產指數等生產效能未受雞糞墊料

重複使用之影響。本研究之雞隻育成率、飼料換肉率、飼養天數、出售體重及生產指數等生產效能，略優於 2019 年社團法人中華民國養雞協會統計資料 (第六版)，國內白肉雞 101 至 105 年度之平均育成率、平均飼料換肉率、平均飼養天數、出售體重分別介於 95.14% － 95.97%、1.46 － 1.57、34.23 － 35.35 日、2.06 － 2.10 kg 及 355 － 398；108 年度 1 至 11 月之平均育成率、平均飼料換肉率、平均飼養天數、平均體重分別為 95.45%、1.43、33.89 日及 2.11 kg。

表 3. 墊料重複使用對白肉雞生產效能之影響

Table 3. Production efficiency of broilers in litter reusing experiment

Readed batch	n[1]	Market (days)[2]	Market weight (kg/bird)	FCR[3]	Survival rate[4] (%)	PI[5]
1	6	35.3 ± 0.72	2.08 ± 0.03	1.49 ± 0.03	96.6 ± 0.41	385 ± 15.1
2	6	35.8 ± 0.53	2.17 ± 0.04	1.50 ± 0.02	96.8 ± 0.40	390 ± 8.56
3	5	35.5 ± 0.47	2.13 ± 0.04	1.50 ± 0.01	95.5 ± 0.66	382 ± 8.87
4	3	35.7 ± 0.67	2.13 ± 0.03	1.49 ± 0.01	96.3 ± 0.81	385 ± 7.38
5	1	36.0 –	2.15 –	1.48 –	97.6 –	393 –

[1] Recorded samples are 6, 6, 5, 3 and 1, respectively.
[2] Mean ± standard error.
[3] Feed conversion rate: feed consumption / weight gain.
[4] Survival rate: market numbers/ chick numbers × 100.
[5] Production index: (survival rate × market weight) / (market days × FCR) × 100.

II. 墊料重複使用飼養白肉雞之墊料厚度變化

在臺灣地區鮮少有墊料重複使用飼養肉雞場域，通常每一飼養批次結束，皆清除雞糞墊料，並進行消毒後，全面舖陳新墊料，再入雛飼養。本研究於試驗期間將 A、B、C 及 D 棟雞舍由水簾端至風扇端劃分 9 個縱斷面及由左側至右側劃分 4 個橫斷面 (圖 1)，使形成 36 個小區，於每批次肉雞出售後，進行墊料重複飼養肉雞之墊料厚度資料收集，量測至重複飼養 3 批次 (102 年 11 月至 103 年 3 月)。結果如表 4，A、B、C 及 D 棟雞舍之墊料厚度隨重複飼養批次增加而增加現象，其中 B 棟雞舍因重複飼養第 3 批次期間飲水器有溢漏，致使墊料潮濕而移除，可能致使量測之墊料厚度較低原因。

表 4. 墊料重複使用批次之雞糞墊料厚度

Table 4. Thickness of litter for different broiler batches in the litter-recycled house

Batch	Sampling date	House A	House B	House C	House D
		(cm)			
1st	Dec. 18. 2013	3.88 ± 0.60	3.41 ± 0.46	4.19 ± 0.86	4.26 ± 0.56
2nd	Feb. 06. 2014	5.77 ± 0.57	5.77 ± 0.59	5.89 ± 0.50	6.33 ± 1.32
3rd	Mar. 28. 2014	8.15 ± 0.75	6.99 ± 0.53	8.15 ± 0.75	8.11 ± 0.73

III. 墊料重複使用飼養白肉雞之雞糞墊料量變化

墊料重複使用於平飼肉雞飼養之墊料量 (濕重) 資料如表 1。結果顯示，墊料量有隨墊料重複使用批次增加而減少趨勢。試驗雞舍 B 棟為雙層雞舍之上層，為減少墊料量對雞舍上層樓板負重，故最多重複使用飼養 4 批後清除雞糞墊料，舖陳新墊料，A、C、D 棟雞舍為墊料重複使用最多 5 批次 (102 年 1 月至 102 年 10 月)。雞舍 B 棟飼養一批白肉雞即清除雞糞墊料，平均雞糞墊料濕重 1.08 kg/ 隻最多 (102 年 9 月至 102 年 10 月)，蘇等 (2015) 分 2 次舖陳稻殼作為墊料，在雞隻出售後清理雞糞墊料時，發現水槽及飼料槽下方的雞糞墊料有發酵現象。本研究結果顯示，墊料量隨著重複使用批次增加而減少，推測係因從第 2 批次開始即無新增墊料且於各批次雞隻飼養期間，雞糞墊料有因被消化分解而失重所致。墊料重複使用飼養肉雞 2、3、4 及 5 批次之平均墊料量 (雞糞墊料重量 ÷ 重複飼養批次期間總入雛數) 分別介於 0.78 － 0.63 kg/ 隻之間。Malone (1992) 整理多篇文獻，收集美國各州資料結果指出，每一批次 (Flock) 飼養 1,000 隻雞平均產生 1.0 (0.7 － 2.0) 噸的雞糞墊料，另 Collins (1996) 指出，每 1,000 隻雞產生 1.1 － 1.4 噸雞糞墊料，本研究結果逐批飼養之雞糞墊料為 1.08 kg/ 隻

與之相近，較程等 (2015) 研究指出，2 － 6 月及 8 － 10 月之開放式有色肉雞飼養場產生雞糞墊料平均分別為 1.91 kg/ 隻及 1.59 kg/ 隻為低，其差異為白肉雞飼養週齡 (5 － 6 週) 少於有色肉雞 (13 週以上)，且禽舍型式，舖陳墊料種類、深度與飼養密度亦有差異。國內外雞糞墊料量少有文獻資料可參考，雖然雞隻排糞量可經代謝試驗測定，例如：畜試土雞 (母) 排糞量 56.30 g/d，含水率 51.68%；紅羽土雞 (母) 排糞量 79.71 g/d，含水率 46.62% (林，2010)，但實際飼養場之雞糞墊料量，受到舖新墊料使用量、禽舍型態、飼養密度及雞糞在飼養期間之分解等多重因素影響。

結　　論

墊料重複使用於白肉雞飼養，在 1、2、3、4 及 5 批次間之平均出售日齡、出售體重、飼料換肉率、育成率及生產指數，分別介於 35.3 － 36.0 日、2.08 － 2.15 kg、1.48 － 1.50、95.5 － 97.6% 及 382 － 394 之間，批次間均無差異顯著性。各批次之雞隻死亡率皆以 1 週齡時高於 2、3、4、5 及 6 週齡 ($P < 0.05$)，且死亡率在批次與週齡間無顯著之交感效應。雞糞墊料的總重量 (濕重) 隨著重複使用批次增加而有增加之趨勢，但以批次飼養之單位 (隻) 雞糞墊料產量計算，在逐批清理雞糞墊料者其平均重量為 1.08 kg/ 隻，而重複飼養 2、3、4 及 5 批次之平均雞糞墊料量則分別介於 0.78 － 0.63 kg/ 隻之間，本試驗未檢測雞糞墊料之重金屬含量，在墊料重複使用飼養白肉雞時，宜留意銅及鋅累積，蘇等 (2016) 指出，單批白肉雞墊料經過 40 天的堆肥化處理後，銅及鋅濃度分別為堆肥化前的 1.20 － 1.63 倍及 1.32 － 1.66 倍)。試驗結果顯示墊料重複使用 5 批次尚不影響白肉雞之生產效能，且可降低單位 (隻) 雞糞墊料量，可為白肉雞飼養業者參考模式之一。

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The effect of litter reuse on the production efficiency of broilers and the quantity of the litter [1]

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Abstract

The aim of this study was to evaluate the effect of litter reuse on the production efficiency of broilers and the quantity of the litter. The recording tables of management, including the date of chicks arrival, chick numbers of each batch, daily death numbers, feed consumption, market date and numbers, total weight of catching, and the reuse times of litter, which were applied to assess the production performance of a broiler farm and to investigate the litter amounts of single batch and reused broiler litter. The results showed the average market days, the average market weight, the average feed conversion rates, average survival rates and production index were 35.3 ~ 36.0 days, 2.08 ~ 2.15 kg, 1.48 ~ 1.50, 95.5 ~ 97.6% and 382 ~ 394, respectively, for the 1st to 5th batches of broiler chickens raised on the reused litter. The results showed no difference among batches. The average death numbers and mortality rates of the first week were significantly higher than those of other week ages ($P < 0.05$), and there was no interaction effect between the batch and week age. The results of investigation on broiler litter yield showed the litter weight per bird sold decreasing as the batch number increased. The average litter weight was cleaned after single batch reached 1.08 kg/bird, while those after two to five batches reached 0.78 ~ 0.63 kg/bird. The results of this study showed that raising 5 batches broiler chickens on reused litter did not affect their performance and could reduce the amount of waste litter. The recycling of litter as bedding material can be applied as a management model for the poultry industry's reference.

Key words: Broiler, Litter, Reuse, Performance.

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冷凍程式對豬精液冷凍解凍後品質之影響 (1)

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摘　要

本試驗探討不同冷凍降溫程式製作豬冷凍精液對解凍後精液品質之影響。採集 5 頭健康杜洛克公豬新鮮精液，以 Lactose-egg yolk (LEY) 精液稀釋液進行稀釋，最終濃度為 5×10^8 cells/mL 並分裝於 0.5 mL 麥管，分別以三組不同冷凍降溫程式進行冷凍精液製作。精液冷凍程序啟動之起始溫度皆為 5℃，第一組以 -3℃/min 之速率降至 -5℃並停留 1 min，之後繼續以 -50℃/min 速率降溫至 -140℃。第二組以 -3℃/min 速率降至 -5℃，隨後以 -40℃/min 之速率繼續降溫，至 -80℃停留 30 sec 後，以 -60℃/min 速率繼續降溫至 -140℃。第三組以 -20℃/min 速率降溫至 -8℃，後以 -70℃/min 速率降溫直至 -140℃，完成降溫之冷凍精液隨即放入液態氮內貯存。凍存精液於解凍後即進行精子品質檢查，試驗結果顯示三種不同冷凍降溫程式處理製作之冷凍精液，其解凍後之精子總活力、前進式活力、各項運動參數及頭帽完整性等性狀表現均無顯著差異。由於第三組冷凍降溫程式製作豬冷凍精液製程所需時間較短，可減少液態氮損耗，建議可提供豬精液冷凍保存採行之參考。

關鍵詞：豬、冷凍精液、冷凍程式。

緒　言

精液冷凍保存有利於種原之維護，提高優良種畜的利用，物種跨國間交流及備份，並減少疫病傳播風險，於現代化畜殖業發展極具深遠之意義 (Bailey *et al.*, 2008; Knox, 2011)。相較於其他物種，豬冷凍精液使用並不普及 (Woelders *et al.*, 2005)；因豬精子對周圍環境較為敏感 (Grossfeld *et al.*, 2008)，解凍後普遍存在活力及受胎率低下等問題，一直不易被廣泛推行 (Garcia-Olivares *et al.*, 2016)。冷凍精液之製作過程通常係於室溫下採集精液後，即進行一系列冷卻步驟，最後貯存於 -196℃液態氮桶。學者專家皆致力探討相關降溫程序，Dalal *et al.* (2018) 研究不同物種如水牛、乳牛、綿羊、豬、馬及兔精液之降溫速率對解凍後精液品質之影響，結論指出因物種不同其精子細胞膜組成亦有所不同，都各自有其合適的冷凍程序。家禽精液冷凍保存，可分為慢速冷凍、兩階段及一階段程式冷凍方式，Santiago-Moreno *et al.* (2011) 之試驗結果，兩階段程式冷凍方式可優化解凍後精液品質。Galarza *et al.* (2019) 之試驗結果指出以兩階段冷凍程式製作綿羊冷凍精液，其解凍後活力、精子細胞膜及 DNA 完整性皆比三階段冷凍程式為佳。Farhana *et al.* (2018) 比較以 5、10 或 15℃/min 三種不同冷卻速率進行牛冷凍精液製作，顯示冷卻速度 10℃/min 之方式，解凍後精子活力、存活率和精細胞膜完整性優於 15 及 5℃/min。目前文獻上有許多製作 0.5 mL 豬冷凍精液之冷凍降溫程式 (Wongtawan *et al.*, 2006; Kaeoket *et al.*, 2010; Purdy *et al.*, 2010; Tomás *et al.*, 2014; Yeste *et al.*, 2014)，但最佳的冷凍降溫程式條件並未被探討。本試驗旨在比較不同冷凍降溫程式處理製作豬冷凍精液，對解凍後包括精子活力、前進式活力、各項運動參數及頭帽完整性等性狀的影響，以期提供較佳豬精液冷凍降溫技術之參考。

材料與方法

I.　精液採集與處理

本研究選擇 5 頭年齡約 1 至 2 歲，生殖能力正常健康之杜洛克公豬供試驗，每週規律採集精液一次，採集後立即進行常規檢查，選取存活率 80% 以上與活力 75% 以上的精液進行冷凍保存試驗。精液稀釋係應用 Beltsville

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thawing solution (BTS，每公升含37.0 g glucose、1.25 g EDTA、6.0 g sodium citrate、1.25 g sodium bicarbonate及0.75 g potassium chloride) 進行 (Johnson *et al.*, 2000)。

II. 精液之冷凍過程

冷凍精液之製作係參考 Westendorf *et al.* (1975) 之方式，精液緩慢添加 BTS 稀釋液，以 1：1 比例進行稀釋，後冷卻至 15℃以 800 x g 離心 10 分鐘，去除上清液後加冷凍稀釋液 (I) (11% lactose 及 20% egg yolk) 稀釋，然後冷卻至 5℃；再添加冷凍稀釋液 (II) (11% lactose, 20% egg yolk, 9% glycerol 及 1.5% Equex STM)，稀釋最終濃度為 5×10^8 cells/mL 後裝填入 0.5 mL 麥管 (Minitüb, Tiefenbach, Germany)，將麥管封口後移置於電腦程式控制儀 (Ice cube 14S，GmbH) 內，分別以三組冷凍降溫程式進行；其中，第一組係參考 Wongtawan *et al.* (2006) 及 Kaeoket *et al.* (2010) 之文獻，起始溫度為 5℃，以 -3℃/min 之速率降至 -5℃並停留 1 min，再以 -50℃/min 速率降溫至 -140℃，製程共約 8 min。第二組係引用 Yeste *et al.* (2014) 及 Tomás *et al.* (2014) 文獻，起始溫度為 5℃，以 -3/min 的速率降至 -5℃，再以 -40℃/min 速率降溫至 -80℃並停留 30 sec，隨即則以 -60℃/min 速率降至 -140℃，製程共約 8 min。第三組係參考 Purdy *et al.* (2010) 文獻，起始溫度 5℃，以 -20℃/min 之速率降至 -8℃，繼以 -70℃/min 之速率降溫至 -140℃，製程共約 3 min。各組精液麥管降溫至 -140℃時，隨即移入液氮桶內貯存。

III. 精液性狀評估

先將解凍用 BTS 精液稀釋液備妥，並回溫至 25℃；迅速從液氮桶內取出所需冷凍精液麥管，浸入 40℃溫水中 30 sec 進行解凍。隨即擦拭麥管表面水分，剪開麥管讓精液流出，並與解凍用 BTS 稀釋液，稀釋最終濃度為 50×10^6 cells/mL，隨後靜置於 37℃培養箱中培養 6 h，期間儘可能避免精液受到溫度變化及光線傷害。解凍後精液以電腦輔助精子分析 (Computer-assisted sperm analysis, CASA) 系統 (VideoTesT-Sperm 2.1, Russia) 進行評估，分析校正係參考 Dziekoska *et al.* (2013) 之方式，分析項目包括精子活力 (Motility)、前進式活力 (Progressive motility, PM)、平均移動路徑 (Velocity average path, VAP)、直線移動速率 (Velocity straight line, VSL)、曲線移動速率 (Curvilinear velocity, VCL)、精子頭部擺動振幅 (Lateral head displacement, ALH)、精子頭部擺動與平均路徑交叉的次數 (Beat cross frequency, BCF)、直線趨勢 (Straightness, STR) 及直線前進之比率 (Linearity, LIN) 等運動能力參數。

IV. 精子頭帽完整性評估

評估精子頭帽完整性採用免疫螢光染色法，步驟係參考Zeng and Terada (2001)之方式操作，取精液樣品30 μL塗抹於預熱之載玻片上，於空氣中自然乾燥，後用 100% 甲醇固定 10 min。取 30 μL 含 100 μg/mL 螢光素異硫氰酸鹽結合花生凝集素 (Fluorescein isothiocyanate-conjugated peanut agglutinin, FITC-PNA) (Sigma -Aldrich, St, Louis, MO, USA) 之 PBS 溶液，滴置於載玻片上，再移於飽和濕度之 37℃培養箱內靜置 30 min，後以 PBS 沖洗再經由空氣乾燥，滴上 5 μL 的 Antifade 溶液 (Molecular Probes, Inc., Eugene, OR) 並蓋上封片，以保持螢光活性。迅速使用光學螢光顯微鏡 (DM 2500, Leica)，以激發波長 480 nm 及射出波長 530 nm 進行 (1,000 ×，油鏡) 鏡檢，隨機計數至少 100 個細胞，且每一樣品重覆計算數 6 次。豬精子頭帽染色及形態判讀方式如下：(1) 精子頭帽出現完整密集螢光，表示頭帽完整；(2) 精子頭帽僅顯現部分螢光，表示頭帽部分受損；(3) 精子頭帽未顯現螢光，表示頭帽之細胞膜及頭帽外膜完全受損。

V. 統計分析

精液解凍後於 37℃下靜置 6 h，並每隔 2 h 檢查其精子活力、精子前進式活力，精子活力等各項移動參數於解凍後體外培養 5 min 及 6 h 檢測，精子頭帽完整率則於解凍後立即進行評估，以探討試驗各組間之差異。所得資料以變異數分析 (ANOVA) 及鄧肯多變域分析法 (Duncan's multiple range test) 比較各組間差異之顯著性，以 $P < 0.05$ 為差異顯著水準。

結果與討論

本試驗比較三種不同冷凍降溫程式製作豬冷凍精液對解凍後精液品質的影響，試驗結果如表 1 所示，各不同的冷凍降溫程式組所製作之豬冷凍精液，解凍後體外培養各時段之精子活力、精子快速前進式活力，於各處理分析相同培養時段間均無顯著差異。採 CASA 方式進行公豬繁殖能力評估已被廣泛探討及應用 (Broekhuijse *et al.*, 2012)，藉由精子運動參數與相關的形態變化進行分析，亦有研究證實與受胎率呈相關性 (Didion, 2008; Vyt *et al.*, 2008)。

精子活力各項運動參數之分析結果如表 2 所示，以三種不同的冷凍降溫程式製作之豬冷凍精液，解凍後體外培養 5 min 及 6 h 的精子活力各項運動參數均無顯著差異。

表 1. 不同冷凍程式對豬冷凍精液解凍後精子活力及前進式活力率之影響

Table 1. The influence of different freezing programs on sperm motility and progressive motility of boar frozen-thawed semen

Freezing programs	Post thawed incubation time				
	Fresh	30 min	2 h	4 h	6 h
	---------- Total sperm motility (%) ----------				
1	91.1 ± 2.5	78.0 ± 6.9	73.2 ± 6.1	50.4 ± 5.7	33.1 ± 7.8
2	90.2 ± 2.1	78.3 ± 4.8	74.8 ± 4.4	52.6 ± 6.8	32.7 ± 6.1
3	89.6 ± 2.1	80.8 ± 4.6	74.8 ± 6.2	53.0 ± 7.3	33.8 ± 6.2
	---------- Progressive sperm motility (%) ----------				
1	79.5 ± 2.7	55.3 ± 7.9	37.9 ± 7.0	23.2 ± 6.2	10.9 ± 6.6
2	78.3 ± 4.3	56.0 ± 4.6	38.5 ± 4.6	24.6 ± 7.0	11.1 ± 5.6
3	78.9 ± 4.3	58.5 ± 5.8	38.6 ± 7.2	24.3 ± 6.9	11.2 ± 7.3

No significant difference was detected among treatment group ($P > 0.05$). Data shown all mean ± S.D. (n = 12). Three types of freezing programs: 1. Cooling rate 3℃/min from 5 to -5℃, 1 min holding at -5℃ and then freezing rate of 50℃/min from -5 to -140℃, 2. Cooling rate 3℃/min from 5 to -5℃, and then freezing rate of 40℃/min from -5 to -80℃, 30 sec holding at -80℃ and then freezing rate of 60℃/min from -80 to -140℃ and 3. Cooling rate 20℃/min from 5 to -8℃, and then freezing rate of 70℃/min from -8 to -140℃.

表 2. 不同冷凍程式對豬冷凍精液解凍後精子運動參數率之影響

Table 2. The influence of different freezing programs on sperm motion characteristics of boar frozen-thawed semen

Freezing programs		Post thawed incubation time	
		5 min	6 h
VAP (μm/s)	1	52.0 ± 7.8	45.0 ± 9.1
	2	49.1 ± 6.5	45.6 ± 6.6
	3	51.8 ± 9.0	42.6 ± 6.3
VSL (μm/s)	1	25.4 ± 3.6	22.0 ± 4.4
	2	23.8 ± 3.2	22.2 ± 3.3
	3	25.3 ± 4.5	20.8 ± 3.0
VCL (μm/s)	1	75.9 ± 9.3	71.8 ± 8.7
	2	72.7 ± 7.5	75.8 ± 8.9
	3	75.5 ± 9.3	68.8 ± 9.3
ALH (μm/s)	1	2.9 ± 0.5	2.5 ± 0.4
	2	2.5 ± 0.3	2.5 ± 0.3
	3	2.7 ± 0.5	2.3 ± 0.3
BCF (Hz)	1	8.3 ± 0.3	8.4 ± 0.1
	2	8.2 ± 0.3	8.5 ± 0.1
	3	8.2 ± 0.1	8.5 ± 0.2
STR (%)	1	96.6 ± 1.3	96.7 ± 0.7
	2	96.0 ± 0.8	96.5 ± 0.6
	3	96.3 ± 0.8	95.9 ± 0.7
LIN (%)	1	39.6 ± 6.3	38.9 ± 5.4
	2	43.0 ± 6.7	37.5 ± 3.6
	3	42.2 ± 3.0	37.5 ± 3.9

VAP, average path velocity; VSL, straight line (progressive) velocity; VCL, curvilinear velocity; ALH, lateral head displacement; BCF, cross-beat frequency; STR, straightness; LIN, linearity; CASA, computer-assisted sperm analysis. No significant difference was detected among treatment group ($P > 0.05$). Data shown all mean ± S.D. (n = 12).
1, 2 and 3 as footnote as Table 1.

精子穿越卵母細胞透明帶後結合完成受精，此過程之成功率與頭帽完整性呈正相關 (Singh *et al.*, 2017)，故進行冷凍條件評估時，有必要檢測解凍後精子頭帽完整性，以辨別冷凍之成效。利用三種不同的冷凍降溫程式製作豬冷凍精液，經解凍後精子頭帽完整性之分析如表 3 所示。結果顯示解凍後三組冷凍精液之精子頭帽完整率分別為 64.3 ± 3.3、66.4 ± 2.7 及 65.8 ± 5.0%，部分頭帽受損率分別為 20.7 ± 6.1、16.1 ± 4.8 及 16.1 ± 3.2%，而頭帽完全受損率為 15.0 ± 2.4、17.5 ± 3.7 及 18.1 ± 5.5%；顯示三種不同的冷凍降溫程式製作冷凍精液的製程，對冷凍精子解凍後頭帽性狀的影響並無顯著差異。

表 3.　不同冷凍程式對豬冷凍精液解凍後精子頭帽完整率之影響

Table 3.　The influence of different freezing programs on the acrosome integrity of boar frozen-thawed sperm

Freezing programs	Intact acrosome (%)	Partially damaged acrosome (%)	Lost acrosome (%)
1	64.3 ± 3.3	20.7 ± 6.1	15.0 ± 2.4
2	66.4 ± 2.7	16.1 ± 4.8	17.5 ± 3.7
3	65.8 ± 5.0	16.1 ± 3.2	18.1 ± 5.5

No significant difference was detected among treatment groups ($P > 0.05$).
Data shown all mean ± S.D. (n = 12).
1, 2 and 3 as footnote as Table 1.

製作冷凍精液的過程可能損害精子、影響精子活力、存活力和受精能力 (Watson, 1990)，理想降溫程序必須能預防冰晶形成，又避免「溶液效應」所產生之細胞脫水與一系列冷凍損傷 (Mazur *et al.*, 1970)，如能減少與抗凍劑接觸時間，則可降低所造成細胞之傷害 (Thurston *et al.*, 2003)，又所採用降溫條件非最佳化，可能導致精子不可逆的損害 (Fiser and Fairfull, 1990; Mazur, 1970)。另冷凍成效也受稀釋液成分、凍存細胞種類及細胞膜通透性等因素影響，皆必須併入考量 (Woelders and Chaveir, 2004)。本研究檢視國外製作豬冷凍精液常用冷凍降溫程式，希望比較確認合適方式，進一步改善程序並簡化流程、減少製作所需時間，同時維持解凍後之精液品質。本試驗比較三組冷凍降溫程式，第一組及第二組製程均約 8 min，第三組因於製程過程中未設置短暫平衡時間，及較快速降溫程序因此只約 3 min。故第三組之冷卻速度較快，因此可以減少電腦程式控制儀液態氮充填量。第一組冷凍程式於 -5℃設定停留 1 min 進行短暫平衡，此設計用以誘導冰晶之形成，文獻提出此步驟之設計原理，為精液樣品冷凍期間會釋出融化之潛熱，導致溫度急劇升高，破壞「最佳」冷卻曲線 (Bwanga *et al.*, 1991; Medrano *et al.*, 2003) ，透過誘導樣品中的冰晶形成，可抵消融合過程所生成之潛熱，改善解凍後精子活力 (Critser *et al.*, 1987)。測試第二組製程於 -80℃停留 30 sec，進行短暫平衡，以維持程式控制儀內部環境與麥管溫度一致。第三組省略此降溫平衡步驟，並採取快速直接凍存，其解凍後活力、前進式活力、精子各項運動參數及精子頭帽完整率等參數，與其他二組並無顯著差異。早期研究公豬精液冷凍理想降溫程序，自 5℃降至 -5℃以 -3 至 -5℃/min 之速率進行，接著則以 -20 至 -50℃/min 之速率降溫至 -196℃為最適條件 (Fisher and Fairfull, 1990; Bwanga *et al.*, 1991)。Kumer *et al.* (2003) 及 Devireddy *et al.* (2004) 認為以降溫速率 -30 或 -50℃/min 製作豬冷凍精液優於 -1℃/min，其中又以 -30℃/min 的降溫速率為佳。Hernandez *et al.* (2007) 等測試降溫速率為 10、40 或 60℃/min，製作豬 0.5 mL 麥管式冷凍精液，結果發現降溫速度並未影響精子品質相關參數。本研究之第三組程式降溫方式係參考自 Purdy *et al.* (2010)，解凍後之精子品質與其他二組比較並無顯著差異。

精子品質體外分析如活力及頭帽完整評估，於後續受精之能力預測非常重要 (Didion *et al.*, 2008; Vyt *et al.*, 2008; Broekhuijse *et al.*, 2012)。但體內受精過程仍須先後達成幾個步驟才可實現，如包括精子進入至輸卵管、精子獲能並啟動頭帽反應，順利穿透卵母細胞及完成激活等過程，所以本研究後續仍待體內受精測試予以印證。本研究利用三組不同的冷凍降溫程式製作豬冷凍精液，其解凍後精子之活力、快速前進式活力、各項運動參數及頭帽完整率等均無顯著差異。惟第三組之冷凍降溫程式處理製程所需時間較短，且可減少液態氮之損耗，建議可提供作為豬精液冷凍保存製作方式之參考。

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Effect of freezing programs on the sperm quality of frozen-thawed boar semen [1]

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Abstract

The objective of this study was to evaluate the effects of different freezing programs on the quality of frozen-thawed boar semen. Semen collected from five Duroc boars were diluted with Lactose-egg yolk extender, which were brought to 5×10^8 cell/mL as the final concentration, and packaged into 0.5 mL plastic straws. Three freezing programs for boar semen cryopreservation were applied and compared: (1) cooling rate -3℃/min from 5 to -5℃, holding at -5℃ for 1 min and then frozen at -50℃/min rate to -140℃, (2) cooling rate -3℃/min from 5 to -5℃, and then frozen at -40℃/min rate to -80℃, holding at -80℃ for 30 sec and then frozen at -60℃/min rate to -140℃, and (3) cooling rate -20℃/min from 5 to -8℃, and then frozen at -70℃/min rate to -140℃ after reaching -140℃, the straws were then plunged into liquid nitrogen. Analysis of sperm quality after thawing showed that the percentage of motility, rapid progressive motility, motility kinetic variables parameters and acrosome integrity were not affected by the different freezing programs. In conclusion, the 3rd freezing program is recommended for boar semen cryopreservation due to the shorter processing time and reduction of liquid nitrogen consumption.

Key words: Boar, Frozen semen, Freezing program.

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臺灣北部地區芻料用燕麥生產與利用之研究 (1)

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摘　要

本研究主要探討芻料用燕麥 (*Avena sativa*) 品種、收穫期及青貯調製利用對燕麥鮮草產量與品質之影響，期提高臺灣北部地區芻料供應量。主要試驗田區位於北臺灣的苗栗縣，試驗期間為 2015 － 2019 年，燕麥於秋天播種，隔年春天收穫。試驗結果顯示，參試的品種以 Swan 表現最佳，鮮草產量約 33.3 － 60.5 mt/ha，乾草產量約 7.7 － 12.4 mt/ha，產量變化主要受溫度與雨量的影響。於 2016 年以帶鎖扣的小型塑膠桶進行青貯料調製，60 天後拆封之 Flieg's 評分 97 － 99 分屬青貯極優的品質。2017 年以大型乾燥機進行燕麥乾燥，分析植體粗蛋白質達 12.61%，中洗纖維 54.05%，酸洗纖維 30.92%，屬品質極優的禾本科乾草。2019 年於桃園市新屋鄉收穫 Swan，鮮草與乾草產量分別為 33.3 mt/ha 及 6.4 mt/ha，並利用圓形膠膜捆包機進行青貯料製作。半年後拆封分析品質，Flieg's 評分 62.8 分屬青貯品質佳。根據本研究結果，適合臺灣北部地區的燕麥種植以 Swan 品種為主，可製作燕麥乾草或青貯料，達燕麥草產業化利用之目標。

關鍵詞：芻料用燕麥、產量、品質、青貯。

緒　言

臺灣地處亞熱帶及熱帶，行政院農業委員會畜產試驗所選育的牧草以適合熱帶生長的牧草為主，如狼尾草 (*Pennisetum purpureum* Schumach) 及盤固草 (*Digitaria decumbens* Stent)，夏季乾草產量高，但冬季產量低，尤其盤固草在北部地區九月以後幾乎不生長。雖有溫帶牧草尼羅草 (*Acroceras macrum* Stapf) 育成，可提供冬季一些乾草，但臺灣冬季缺少可利用的芻料仍是普遍的現象。畜產試驗所新竹分所利用高海拔山坡地，選育一些冬季牧草試種，如燕麥 (*Avena sativa*)、埃及三葉草 (*Trifolium alexandrinum* L)、棒頭草 (*Polypogon fugax*) 等作為冬季芻料的來源 (卜等，1990)。但受限於臺灣冬季多雨日照不足，無法調製為乾草，產業利用率偏低。因此，如何藉由收穫調製方法，生產可應用於酪農產業的冬季牧草為本研究之主要目標。

燕麥 (*Avena sativa* L.) 又稱普通燕麥，主要作為穀粒用，為溫帶地區一年生的作物。1979 年臺灣大學農藝學系選育出「燕麥臺大選一號」屬普通燕麥，對溫度與光照長度敏感，需要低溫及長日照的生長環境才能開花結實 (劉及曾，1984)。「燕麥臺大選一號」秋作 (11 月) 種植，於抽穗後 10 天採收，株高為 132.2 cm，整株鮮草產量可達 32.8 mt/ha，產量相當高，可整株利用青飼或青貯調製作為乳牛飼養的芻料來源 (李，1988)。臺灣早期芻料用的燕麥品種還有日本引進之品系 (日向、前進) 等。裸燕麥 (*Avena nuda* L.) 與普通燕麥相似，但子實外層的護穎容易脫落，因此稱為裸燕麥。紅燕麥 (*Avena bvzantina* Koch) 又稱阿爾及利亞燕麥，臺灣早期也有引進作為芻料用。澳洲天鵝燕麥 (Swan oat) 為紅燕麥與普通燕麥雜交選育之後裔 (黃，1977)。苗栗縣農會於後龍地區試種卡諾燕麥 (Kanota oat) 為紅燕麥品種， 2010 年 10 月種植隔年 4 月上旬收穫，株高都可達 135 － 140 cm，鮮草產量約 30 mt/ha (蕭及梁，2013)。黑燕麥 (Avena strigosa Schreb) 品種 Saia 則較適應高溫的生長環境，畜產試驗所恆春分所試種黑燕麥 Saia，2014 年 11 月種植隔年 3 月收穫，乾重產量可達 10.5 mt/ha (乾物率 45.5%)，也是相當不錯的黑燕麥品種 (朱等，2018)。品種、種植期、收穫期及生長期間溫度與雨量的變化，顯著影響芻料用燕麥的產量與品質 (Coblentz *et al.*, 2011, 2012; Contreras-Govea and Albrecht, 2006)。

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臺灣農地的利用以種植水稻為主，於第二期水稻收穫後 (10 － 11 月) 及第一期水稻插秧前 (2 － 3 月) 的中間空窗期，進行冬季裡作燕麥的種植與生產，不僅可增加乳牛冬季芻料的供應量，提高農地的利用率，且可減少冬季裡作田間雜草的管理。但對於適合臺灣北部地區燕麥種植的品種、適播期、收穫期及青貯調製利用，尚缺乏詳細的產量調查與品質分析。因此，本研究主要於 10 － 11 月播種，隔年 2 － 4 月收穫，持續 4 年進行燕麥品種試種與青貯調製之研究，並於桃園市新屋區進行 1 ha 試種與青貯調製，調查產量與分析品質，期建立臺灣北部地區冬季芻料用燕麥的生產與產業應用模式，提供草農與酪農等業界參考。

材料與方法

I. 試驗地點與氣象資料收集

試驗地點為畜產試驗所新竹分所 (以下略稱新竹分所) 的牧草試驗區，位於苗栗縣西湖鄉五湖村 (24º 31’43.4” N 120º 16’14.2” E)，面積為 50 × 60 m^2 及 30 × 60 m^2 二區，試驗期前及試驗期間，每試驗區採取土樣 4 點，由苗栗區農業改良場土壤研究室協助土壤分析，包括土壤有機質、有效性磷、有效性鉀、鈣、鎂。依水：土 = 1：1 玻璃電極法測土壤 pH 值。利用中央氣象局網站與苗栗區農業改良場氣象觀測站之資料，收集新竹分所試驗區與桃園市新屋區試驗場域之氣溫與雨量變化。

II. 試驗品種與田間設計

2015 年 11 月 10 日於新竹分所種植 3 燕麥品種 (Sweet one、Winner、Swan)，採 3 重複之 RCBD 試驗設計規劃試驗區，每小區為 15 × 10 m^2，小區間距為 1 m，分別於 2016 年 2 月 22 日、3 月 7 日及 3 月 28 日收穫。2016 年 12 月 14 日只種植 Swan 單一品種約 0.5 ha，採 RCBD 田間試驗設計，分別於 2017 年 3 月 28 日及 4 月 10 日收穫。2017 年 10 月 30 日種植燕麥 Swan 及 Mount one 進行二品種之比較，採 2 重複之 RCBD 田間試驗設計，於 2018 年 3 月 5 日收穫。2018 年則於桃園市新屋區實證場域進行試驗，於 10 月 25 日種植 Swan 約 1 ha，採 RCBD 田間試驗設計，2019 年 1 月 22 日及 2 月 12 日收穫。依慣行法整地並施用臺肥複合肥料 5 號 (N：P：K = 10：20：20) 為基肥，共計 N：P：K = 33：66：66 kg/ha。

III. 燕麥產量調查與品質分析

於試驗區逢機取 4 個取樣點，每點 1 m^2，調查株高、單位面積鮮草產量。並取 1 kg 樣品經 80℃烘乾後，計算乾物率。樣品磨成粉狀，以 2 mm 的篩網篩過，分析水分、粗蛋白質 (Crude protein, CP) (AOAC, 2000)。酸洗纖維 (Acid detergent fiber, ADF)、中洗纖維 (Neutral detergent fiber, NDF) 以 ANKOM200 纖維分析儀進行 (ANKOM Technology Crop., Fairport, NY)。酸洗木質素 (Acid detergent lignin, ADL) 的分析則是以烘乾後的酸洗纖維，於玻璃坩鍋內加入 25mL 72% 的濃硫酸 (H_2SO_4) 攪拌至糊狀，每小時加入 2 mL 72% 濃硫酸，持續 3 小時，然後抽真空過濾，在以 90℃熱水清洗及過濾 5 次，經低溫乾燥 24 小時，秤重並計算酸洗木質素含量。

IV. 燕麥青貯調製

2016 年 2 月 22 日燕麥 Swan 品種收穫後，以機器細切，以自然風乾的方式將 1,500 kg 燕麥草萎凋至水分約 60%，開始進行燕麥青貯製作。玉米粉添加量為燕麥鮮重之 15%，並於每公噸混合原料中添加 1 kg 市售安畜－ M® 乳酸菌與酵母菌混合菌料 (*Lactobacillus* spp. 及 *Saccharomyces* spp.)，總菌數約為 1 × 10^8 cfu/g ，利用完全混合日糧調製機混合均勻後，分別充填於 30L 的塑膠桶，每桶 26kg 共 60 桶，60L 的塑膠桶，每桶 50kg 共 30 桶。於牛舍室內存放 60 天後開封取樣分析。約 1,500 kg 的燕麥青貯料進行泌乳牛試驗，比較燕麥青貯料與市售青割玉米青貯料對泌乳牛產乳量與乳品質之影響 (王等，2018a)。

2019 年 2 月 12 日於桃園市新屋區進行大面積的燕麥收穫與青貯料調製，參考盤固草半乾青貯 (卜，1995；卜等，1998) 的收穫調製方式進行，以低重心割草機進行燕麥剪草，於田間萎凋一天，第二天翻草一次，直到燕麥水分降至 60% 左右開始集草，以圓形打包機進行打包，並利用膠膜捆包機將圓柱形草球捆塑膠膜共二圈，然後置於戶外水泥地存放。貯存半年後開封取樣分析。

燕麥青貯品質評分 (Flieg’s score)，新鮮青貯料分析乙酸、丙酸、丁酸及乳酸等揮發性脂肪酸含量 (李，1985; Jones and Kay, 1976)。依青貯料中乙酸、丁酸和乳酸進行青貯品質評分，評分 40 － 60 分為可接受，60 － 80 分為良好青貯料， 80 分以上為發酵優良的青貯料 (Mcculough, 1978)。

V. 燕麥乾燥

2017 年 3 月收穫之 Swan，於試驗區以人工剪草機收割後，於田間萎凋一天，經機器細切後，以新竹分所研

發之大型乾燥機，乾燥有效空間為 25 m^3，進行約 48 小時乾燥，先以 80℃熱風連續乾燥 8 小時，再以送風 16 小時，此循環進行兩次後，以大型雙層塑膠袋抽真空後密封存放。共收穫乾燥約 2,000 kg 燕麥乾草進行泌乳牛飼養試驗，比較國產燕麥與進口燕麥乾草對泌乳牛產乳量與乳品質之影響 (王等，2018b)。

VI. 試驗資料分析

利用 SAS 統計分析系統的一般線性模式 (General liner model) 進行變方分析。以 F-test 檢測各效應之顯著性，並以最小顯著性差異法 (Least significant difference test, LSD) 比較各處理間之差異 (SAS, 2015)。若二處理間平均值間的差異大於理論值 $LSD_{0.05}$，表示處理平均值間有顯著差異。

結果與討論

臺灣北部地區種植燕麥的季節大約在每年 10 － 11 月，收穫期約在隔年 3 月，為冬季裡作的栽培模式。依據苗栗地區溫度與雨量的變化結果 (如表 1)，2015 年 11 月 10 日種植至隔年 2 月 22 日生育期約 104 日，平均氣溫 16.9℃、累積溫度 1,754.8℃、降雨天數 27 天、累積降雨量 348.5 mm。2015 年 11 月 10 日至 2016 年 3 月 28 日累計降雨天數增加至 43 日，累計降雨量 665.5 mm，三月為北部地區的梅雨季節。2016 年因配合前一期青割玉米的收穫，12 月 14 日才播種，於 2017 年 4 月 10 日收穫，累計溫度達 2,016.4℃，降雨天數 24 天，累積降雨量為 210.0 mm，2016 至 2017 年燕麥的生長屬於乾旱期且降雨量偏低。2017 至 2018 年燕麥生長期的平均溫度為 18.9℃，顯著高於前二年燕麥生育階段的氣溫，降雨天數與累積降雨量亦高於前二年的變化。2018 － 2019 年燕麥生育期間桃園市新屋區的平均溫度達 19.0℃，降雨天數增加但降雨量偏低。由歷年溫度的變化得知，燕麥生育期間的平均氣溫有逐年上升的趨勢。

表 1.　2015 － 2019 年臺灣北部地區燕麥種植試驗期間溫度與雨量的變化

Table 1.　Changes of temperature and precipitation for forage oat grown in northern Taiwan from 2015 to 2019 experimental period

Growth period	Growth days	Temperature		Precipitation	
		Daily mean	Cumulated	Raining day	Total
	d	℃	℃	d	mm
Miaoli					
2015 － 2016					
11/10 － 2/22	104	16.9	1,754.8	27	348.5
11/10 － 3/07	118	16.7	1,974.3	27	349.0
11/10 － 3/28	139	16.6	2,302.2	43	666.5
Miaoli					
2016 － 2017					
12/14 － 3/28	105	16.6	1,743.1	21	184.0
12/14 － 4/10	118	17.1	2,016.4	24	210.0
Miaoli					
2017 － 2018					
10/30 － 3/05	127	18.9	2,207.2	80	583.7
Xinwu					
2018 － 2019					
10/25 － 1/22	90	19.6	1,764.6	38	165.3
10/25 － 2/12	111	19.0	2,300.2	41	168.7

根據 2016 年土壤採樣分析結果，新竹分所試驗田區之 pH 5.56 ± 0.17、有機質 1.85 ± 0.25%、有效性磷 10.61 ± 1.86 ppm、交換性鉀 33.67 ± 8.06 ppm、交換性鈣 585.11 ± 93.70 ppm、交換性鎂 198.44 ± 18.06 ppm。2019 年桃園新屋區試驗場域土壤採樣分析結果，pH 7.23 ± 0.19、有機質 1.94 ± 0.36%，有效性磷 7.93 ± 0.46 ppm、交換性鉀 82.50

± 30.51 ppm、交換性鈣 1,349.00 ± 73.66 ppm 、交換性鎂 206.75 ± 11.70 ppm (data not shown)。新竹分所的土壤偏酸性，桃園市新屋區則為鹼性土壤且交換性鉀與鈣含量高於新竹分所試驗地。

2015 年 11 月冬季試種三個燕麥品種，於隔年 2 月 22 日、3 月 7 日及 3 月 28 日收穫其產量調查 (如表 2)。生育日數 104 天，Sweet one 株高為 82.3 cm，鮮重 33.7 mt/ha，乾重 7.1 mt/ha，同期 Swan 的株高與乾物產量優於 Sweet one 與 Winner 品種。2016 年 3 月 7 日調查，燕麥已進入抽穗期 (生育日數 118 天)，Swan 的株高為 134.6 cm，鮮重為 39.0 mt/ha，乾重 7.8 mt/ha，產量表現皆高於 Sweet one 與 Winner 這兩品種。當生育後期 (生育日數 139 天) Sweet one 與 Winner 的鮮重產量降低，主要因結穗後莖稈開始枯黃、結的穀穗被麻雀採食或掉落田間，尤其以 Winner 乾重減少最為嚴重。根據產量表現，以 Swan 這品種為臺灣北部地區優先種植為考量。2017 － 2018 年進行 Swan 與 Mount one 的產量比較試驗 2018 年 3 月 5 日調查 Swan 的株高為 103.1 cm，鮮重達 60.5 mt/ha，乾重 12.4 mt/ha。同期 Mount one 的鮮重為 49.5 mt/ha，乾重 9.8 mt/ha，隨生育日期增加乾重產量於 3 月 19 日達 14.9 mt/ha，3 月 26 日乾物產量減少為 12.9 mt/ha。燕麥成熟後期乾物產量降亦見諸於其他報告 (Coblentz *et al.*, 2011)。由乾重的變化得知 Mount one 產量到後期才達到 Swan 的產量，表示 Mount one 較 Swan 晚熟，可能較不適合於裡作期間種植，且晚熟品種會影響一期水稻的種植。

表 2. 三種不同燕麥品種於 2016 － 2018 年在臺灣北部秋季裡作產量之比較

Table 2. Comparison of 3 different varieties of forage oat for forage yield grown in fall crop in 2016 ~ 2018

Variety	Harvest date	Growth day	Plant height	Fresh weight	Dry weight
	2016	d	cm	---------- mt/ha ----------	
Sweet one	2/22	104	82.3^{e}	33.7^{gh}	7.1^{d}
Winner	2/22	104	62.3^{f}	30.0^{h}	6.0^{d}
Swan	2/22	104	97.6^{d}	33.3^{gh}	7.7^{d}
Sweet one	3/7	118	110.7^{c}	36.7^{efg}	7.3^{d}
Winner	3/7	118	78.3^{e}	34.7^{fg}	6.9^{d}
Swan	3/7	118	134.6^{a}	39.0^{ef}	7.8^{d}
Sweet one	3/28	139	113.1^{bc}	29.7^{h}	6.7^{d}
Winner	3/28	139	77.8^{e}	29.3^{h}	5.9^{e}
Swan	3/28	139	134.8^{a}	32.7^{gh}	7.7^{d}
	2018				
Swan	3/05	127	103.1^{cd}	60.5^{a}	12.4^{b}
Mount one	3/05	127	105.4^{cd}	49.5^{b}	9.8^{c}
Mount one	3/12	134	101.3^{cd}	40.0^{de}	8.0^{cd}
Mount one	3/19	141	122.5^{b}	44.3^{cd}	14.9^{a}
Mount one	3/26	148	133.6^{a}	46.8^{bc}	12.9^{b}

$^{a, b, c, d}$ Means within the same year in the same column with different superscrips differ ($P < 0.05$).

以同一品種 Swan 比較歷年產量的變化 (如表 3)，鮮重大約分布在 30 － 40 mt/ha，乾重 7 － 10 mt/ha。2018 年 3 月 5 日鮮重與乾重特別高，參考 2017 － 2018 年燕麥生育期間累積降雨量達 583.7 mm 較前幾年生育期的累積降雨量高，表示燕麥生育期若有水分的供應可提高其產量。本試驗結果與「燕麥臺大選一號」秋作 (11 月) 種植，於抽穗後 10 天採收，鮮草產量可達 32.8 mt/ha (李，1988) 的結果相近。根據 Contreras-Govea and Albrecht (2006) 於美國威斯康辛州進行燕麥試驗，春播燕麥的生育平均溫度由 7℃ 逐漸升高至 21℃，秋播燕麥 23℃ 逐漸降至 10℃，春播夏收的燕麥平均乾物產量為 7.7 mt/ha，秋播冬收的乾物產量為 6.7 mt/ha。雖然威斯康辛州的氣溫變化與臺灣不同，但其乾物產量約 7 － 8 mt/ha 與本試驗結果相當接近。臺灣恆春地區黑燕麥草生育期 (74 － 105 天)，乾物產量 5.37 － 6.79 mt/ha，生育日數達 119 天乾物產量為 10.54 mt/ha (朱等，2018)，黑燕麥產量顯著高於本試驗之產量。除品種差異之外，累積氣溫也是影響芻料用麥類如黑小麥 (Triticale) 乾物產量之重要因素 (Coblentz *et al.*, 2018)。

表 3.　於 2016 － 2019 年試驗期間生長日數對芻料用燕麥 Swan 品種鮮重與乾重之影響
Table 3.　Effects of growth days on fresh and dry weights of forage oat cv. Swan in 2016 ~ 2019

Growth year	Harvest date	Growth days	Plant height	Fresh weight	Dry weight
		d	cm	---------- mt/ha ----------	
2016	2/22	104	97.6^{e}	33.3^{c}	7.7^{cd}
2016	3/07	118	134.6^{b}	39.0^{b}	7.8^{cd}
2016	3/28	139	134.8^{b}	32.7^{c}	7.7^{cd}
2017	3/28	105	117.3^{d}	29.3^{d}	6.7^{d}
2017	4/10	118	116.0^{d}	34.8^{c}	8.8^{bc}
2018	3/05	127	103.1^{e}	60.5^{a}	12.4^{a}
2019	1/22	90	126.2^{c}	33.3^{c}	6.4^{d}
2019	2/12	111	154.1^{a}	40.3^{b}	9.8^{b}

$^{a, b, c, d, e}$ Means in the same column with different superscrips differ ($P < 0.05$).

燕麥品種對營養成分之影響 (如表 4)，2016 年同期收穫 Swan 蛋白質略低於 Winner (7.65% *vs.* 8.25%)，中洗纖維略高 Winner (63.34% *vs.* 60.43%) 差異並不顯著。2018 年 3 月 5 日收穫時 Swan 品種植體的粗蛋白質達 14.82% 顯著高於 Mount one 的 9.86%，Swan 品種的中洗纖維及酸洗纖維則顯著低於 Mount one，表示在相同生育日數的條件下，Swan 的品質優於 Mount one。但以 Mount one 而言，2018 年 3 月 5 日與 3 月 26 日比較，粗蛋白質含量為 9.86% 與 6.25% 差異顯著，但 3 月 12 日與 3 月 19 日收穫期的粗蛋白質介於 7.57% 至 8.80% 之間，主要因本次試驗為大面積的田間栽培，燕麥穀粒成熟的不一致性，有些穀粒掉落或是正在發育，生育期間蛋白質含量的變動呈現不規則。

表 4.　不同年度種植的芻料用燕麥品種對其植體化學組成之影響
Table 4.　Effects of variety on chemical compositions of forage oat grown in different years

Variety	Growth day	CP	NDF	ADF
		---------- % of dry base ----------		
	2016			
Sweet one	104	7.90^{a}	62.27^{a}	28.63^{a}
Winner	104	8.25^{a}	60.43^{a}	29.11^{a}
Swan	104	7.65^{a}	63.34^{a}	28.78^{a}
	2018			
Swan	127	14.82^{a}	51.03^{d}	32.21^{c}
Mount one	127	9.86^{b}	59.06^{ab}	36.59^{b}
Mount one	134	7.57^{cd}	61.71^{a}	38.32^{a}
Mount one	141	8.80^{bc}	58.50^{c}	35.89^{b}
Mount one	148	6.25^{d}	57.03^{c}	36.66^{ab}

$^{a, b, c, d}$ Means within the same year in the same column with different superscrips differ ($P < 0.05$).
CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber.

同一品種 Swan 在不同年度間的營養成分變化 (如表 5)，2016 年收穫燕麥植株的粗蛋白質為 7.65%，2017 年的粗蛋白質維持於 10.67 － 12.61% 之間。2018 年粗蛋白質為 14.82%，2019 年粗蛋白質介於 11.06% 與 5.62% 之間，Swan 品種蛋白質含量的變化最高達 14.82%，最低 5.62%。表示不同收穫期及栽培條件將影響燕麥粗蛋白質含量的變化。卜等 (1993) 與李等 (1991) 探討不同割期對盤固草產量、化學成分與營養價值之影響，以同一年度同一期盤固草而言，產量隨生長日數增加，粗蛋白質含量隨生長日數增加而減少，粗纖維、酸洗纖維及木質素則隨生育日數增加而增加。以芻料用燕麥而言，燕麥抽穗後期穀粒成熟掉落，其粗蛋白質含量可能僅 5.62%，無法維持於 10 － 12% 高蛋白質之營養成分，此為燕麥收穫時須注意之事項。

表 5. 不同年度種植芻料用燕麥 Swan 品種其生長日數對植體化學組成之影響

Table 5. Effects of growth days on chemical compositions of forage oat cv. Swan grown in different years

Growth year	Growth day	CP	NDF	ADF	ADL	Hemi-cellulose	Cellulose
		% of dry base					
2016	139	7.65[c]	63.34[a]	28.78[d]	—	—	—
2017	105	10.67[b]	59.47[b]	33.89[b]	6.25[b]	25.58[a]	27.64[b]
2017	118	12.61[b]	54.05[c]	30.92[c]	6.30[b]	23.13[b]	24.62[c]
2018	127	14.82[a]	51.03[c]	32.21[bc]	—	—	—
2019	90	11.06[b]	63.39[a]	39.97[a]	7.65[ab]	23.41[ab]	32.32[a]
2019	111	5.62[d]	66.58[a]	41.72[a]	8.61[a]	24.86[ab]	33.11[a]

[a, b, c, d] Means in the same column with different superscripts differ (P < 0.05).

CP: crude protein NDF: neutral detergent fiber, ADF: acid detergent fiber.

本研究以 2016 年 2 月 22 日收穫的 Swan 鮮草 (約抽穗後 14 天)，於新竹分所進行青貯調製發酵 60 天，分別於 2016 年 4 月 25 日及 27 日開封進行青貯品質的測定 (如表 6)。pH 為 3.99 及 4.00，Flieg's 評分 99.5 及 97.0 皆屬非常優良的青貯品質。另 2019 年 2 月 12 日於桃園新屋進行燕麥膠膜捆包青貯料製作，貯存 156 天後開封青貯品質 (如表 7)，膠膜捆包的內層青貯料 pH 4.66，其 Flieg's 評分 62.8，靠近膠膜捆包外層的青貯料 pH 4.92 其 Flieg's 評分 50.0，內層的青貯品質優於外層。膠膜捆包青貯品質不如塑膠桶桶裝 (如表 6) 的結果，主要因在貯存過程膠膜容易破損，塑膠桶則可以維持發酵良好的狀態。另方面，2016 年的塑膠桶試驗有添加乳酸菌等促進發酵，2019 年膠膜捆包並未添加乳酸菌等，可能也是造成膠膜捆包青貯料品質不佳的原因。

表 6. 芻料用燕麥 Swan 品種以桶裝式青貯 60 天後之青貯品質

Table 6. The silage quality of forage oat cv. Swan ensiled in the plastic bucket 60 days after ensiling

Date of sampling	pH	Acetic acid	Lactic acid	Flieg's score
2016		% o		
4/25	3.99	0.39	2.30	99.5
4/27	4.00	0.48	2.16	97.0

表 7. 芻料用燕麥 Swan 品種以膠膜捆包機捆包 156 天後之青貯品質

Table 7. Effects of sampling location on the silage quality of forage oat cv. Swan 156 days after ensiling with round bale

Location of sampling	pH	Acetic acid	Lactic acid	Flieg's score
		%		
Center	4.66[b]	0.57[b]	0.55[a]	62.8[a]
External layer	4.92[a]	0.93[a]	0.20[b]	50.0[b]

[a, b] Means in the same column with different superscrips differ (P < 0.05).

根據李 (1988) 的試驗，燕麥臺大選一號秋季 10 月種植，大約於抽穗後 17 － 24 天，進行青貯料製作，青貯 Flieg's 評分達 72.2 － 73.1，紅燕麥青貯 Flieg's 評分達 84.0 － 82.7 分。芻料用高粱通常在抽穗 20 天後可製得更好之青貯料，Flieg's 評分約在 80 分左右 (蕭等，1994)。國產芻料狼尾草、盤固草、蘇丹草 (*Sorghum sudanense*) 及青割玉米 (*Zea mays*) 等，青貯 60 天之評分點，除盤固草 64 分外，另外三種皆超過 80 分達到優良的等級。青貯調製過程如能細切，充分的壓實再配合良好的密封，較易調製良好的青貯料 (盧及許，2001)。尼羅草臺畜草一號 (*Acroceras macrum*) 以膠膜捆包機進行青貯調製，青貯評分為 63 分。尼羅草細切 5 cm 以下，以香腸式青貯法進行青貯調製，不論以大型或小型香腸式填充機進行填充，均能得到品質良好之青貯料 (盧及許，2004)，本試驗亦獲得類似的結果，膠膜捆包製作燕麥青貯料的品質評分約 62.8 － 50.0 分。

此次於新竹分所製作之燕麥青貯品質非常優良的原因，主要因考量青貯調製的各種因素，包括燕麥的成熟期 (李，1988)，燕麥進行細切至 5 － 10 cm (盧及許，2001)，以自然風乾的方式將燕麥水分調整至約 60% (蕭等，

2000)，以青貯桶方式進行壓實達厭氣方式 (盧及許，2001)，添加玉米粉以增加碳水化合物含量 (盧，1990)，並於添加 1 kg/mt 市售安畜－ M® 乳酸菌與酵母菌混合菌料 (*Lactobacillus* spp. 及 *Saccharomyces* spp.)，市售菌料活菌總菌數約為 1×10^8 cfu/g，燕麥青貯料品質達 Flieg's 評分 90 分以上之標準。王等 (2020) 將不同乾物率的燕麥與添加不同乳酸菌密封於真空袋，貯存 18 個月後，評估不同乾物率的燕麥、燕麥 / 苜蓿混植與各種乳酸菌接種的結果。試驗結果顯示，低乾物率 (26.8%) 的燕麥接種 *L. acetotolerans* SOR-4 的菌株，青貯品質達 Flieg's 評分 94.8 分。高乾物率 (48.2%) 的燕麥接種 *L. acetotolerans* SOR-4 的青貯品質達 Flieg's 評分 72.3 分與商業品種差異不大。本試驗添加乳酸菌以青貯桶製作燕麥青貯料的結果，Flieg's 評分 99.5 及 97.0 分表示添加乳酸菌有助於青貯品質的提升。

探討飼糧中添加燕麥青貯料對荷蘭牛泌乳性能之影響，分別於夏、冬季各進行一次，將 8 頭荷蘭泌乳牛依體重、乳量、胎次與泌乳天數逢機分成兩組。以燕麥青貯取代 30% 青割玉米青貯的乾基混合於飼糧中進行餵飼。試驗結果，國產燕麥青貯料與市售青割玉米青貯料比較，對牛群採食量、產乳量及乳品質並無顯著的影響，表示國產燕麥青貯料作為泌乳牛之飼糧來源，並不影響產乳量與乳品 (王等，2018a)。利用新竹分所研發之大型乾燥機組進行燕麥草的乾燥，其乾物質 89.68%、粗蛋白質 14.82%、中洗纖維 51.03%、酸洗纖維 32.21%。進口燕麥草其乾物質 90.23%、粗蛋白質 10.26%、中洗纖維 47.7%、酸洗纖維 28.24%。泌乳牛對進口燕麥乾草乾物質採食量為 19.3 kg/day 略高於國產燕麥乾草的 18.3 kg/day。根據現場飼養觀察，國產燕麥乾草質地細緻蓬鬆、葉面較寬且穀穗明顯，切短約 3 － 5 cm， 相較於進口燕麥乾草之乾扁粗糙、枝稈細硬且少穀穗，牛隻尚未適應此型態之國產燕麥草會挑草，以致於採食量較進口草低，採食進口燕麥草與國產燕麥草的產乳量分別為 20.9 及 23.7 kg，國產燕麥草略高於進口草。主要因國產燕麥草保留大部分穀粒之營養成分，利用大型乾燥機可以確保國產燕麥草之品質，尤其粗蛋白質顯著高於進口燕麥草，並表現在產乳量上 (王等，2018b)。

結　　論

根據本試驗結果，參試的芻料用燕麥品種以 Swan 表現最佳，鮮草產量最高可達 60.5 mt/ha，以塑膠桶添加乳酸菌等方式進行青貯料調製，其青貯評分達 90 分以上。農民於實證場域進行產業化的大面積青貯調製利用，則以圓形膠膜捆包機進行青貯料調製，其青貯品質評分達 60 分。臺灣北部地區秋季種植燕麥於隔年春天收穫，於適當收穫期以機械乾燥，芻料用燕麥 Swan 的粗蛋白含量可達 10 － 14.82%，屬於高品質的燕麥乾草，具未來產業推廣利用之價值。

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Production and utilization of forage oat grown in northern Taiwan [1]

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Abstract

The objectives of the study aimed to investigate the effects of variety, harvest period, and ensiling technology on the forage yield and quality of forage oat (Avena sativa), in attempt to increase forage supplement in northern Taiwan. Forage oats were sown in fall and harvested next spring between 2015 ~ 2019. The experimental field was located in Miaoli in northern Taiwan. The results showed that forage oat cv. Swan was the best among the testing varieties. The fresh forage yield of Swan oats ranged from 33.3 to 60.5 mt/ha, and the dry forage yield ranged from 7.7 to 12.4 mt/ha, respectively. Forage production was affected by temperature and rainfall. Silage was made in small plastic pails with screw caps, and the forage quality was determined as 60 days after ensiling in 2016. The silage quality was excellent with Flieg's scores, ranged from 97 to 99 points. Forage oat hay was produced by large dryer in 2017. The forage quality of oat hay was satisfactory: The crude protein, neutral detergent fiber, and acid detergent fiber were 12.61, 54.05, and 30.92%, respectively. The fresh and the dry forage yield of Swan oat planted in Xinwu, Taoyuan in 2019 were 33.3 and 6.4 mt/ha, respectively. Silage round bale was wrapped with the plastic membrane in the field. The silage quality was satisfactory with Flieg's score being 62.8. The results showed that forage oat cv. Swan may be commercial produced in the form of oat hay or silage for dairy cows in northern Taiwan.

Key words: Forage oat, Forage yield, Forage quality, Silage.

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The Effect of caponization on the blood physiological value of Taiwan male native chickens (1)

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Abstract

The purpose of this study was to investigate the effects of caponization on the packed cell volume (PCV), plasma pH, and plasma physiological values of Taiwanese male native chickens at different ages. For the experiment, the rooster of Taiwan Livestock Meat No. 13 was selected. The chickens were castrated at the 10th week of age and were fed with feed during the growth period (10 ~ 18 weeks of age) and the fattening period (19 ~ 28 weeks of age). Caponized or sham male native chickens were selected at the 14th week in this experiment. The treatment groups were divided into a castrated group and a slip group according to the re-development of the comb. After the chickens were fasted for 12 hours, blood samples were collected from individual chickens every two weeks, while 20 chickens from each treatment group were randomly sampled every time. The results showed that the capons (16 ~ 28 weeks old) had the highest plasma inorganic phosphorus, potassium ion and total cholesterol concentration. Besides, the capons (20 ~ 28 weeks old) had the lowest PCV and plasma pH values. The capons had also the lowest testosterone concentration at the 28th week of age, followed by the slip chickens and the sham group, respectively ($P < 0.05$). Capons and slip chickens have significantly higher plasma calcium ions, total protein, albumin, globulin, triglycerides, low-density lipoprotein, high-density lipoprotein, and blood suppression ($P < 0.05$), compared with roosters, however with a significantly lower concentration of plasma uric acid ($P < 0.05$). In addition, the activities of plasma creatine kinase and alkaline phosphatase were significantly higher in capons whereas the sham group had significantly higher concentrations of plasma creatinine and total hydroxyproline ($P < 0.05$). Furthermore, blood PCV value increased in both capons and slip chickens with increasing age, and peaked at the 20th and 26th weeks of age, respectively. In addition, the concentrations of plasma total calcium in sham, slips and capons, peaked at the 18th week of age and declined at the 22th week of age. Moreover, the concentrations of plasma inorganic phosphorus in sham, slips and capons, were reduced significantly with age. In conclusion, the results of these tests revealed that castration will significantly affect the PCV, plasma pH and certain components between 4 and 6 weeks, mainly due to androgen functions, including erythropoiesis, protein, lipid, bone, and connective tissue synthesis.

Key words: Age, Blood parameters, Caponization, Male native chicken, Testosterone.

Introduction

Capons are male chickens whose testes have been surgically removed. Because of the resultant androgen deficiency, secondary male sexual characteristics (comb, wattle, fighting, mount-bite behavior, and vocalization) are degenerative, and maturity regresses to an immature stage. Capons, commonly known as eunuch chickens, represent a number of locally produced chickens favored by Taiwanese consumers, which use the male Taiwan native chickens or male Taiwan game chickens. In Taiwan, capons are the main source of chicken meat in Hakka residence and have the highest unit price of all chicken species.

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In general, the rearing period of capons is longer (24 ~ 32 weeks) than that of the Taiwan native chicken; and the live weight is also heavier. Capons are divided into heavy type capons (above 3.5 kg of live body weight) and light type capons (below 3.5 kg of live body weight). Taiwanese consumers traditionally prefer heavy types of capons to the broilers and are willing to pay a premium for capons.

Numerous reports have pointed out the influence of surgical caponization on the behavior (Wang, 2001), growth performance (Wang, 2001; Lin and Hsu, 2002; Murawska *et al.*, 2019), comb area, feather scores and rectal temperature (Lin and Hsu, 2003a), organ and carcass part ratios (Lin and Hsu, 2003b), skin and muscle colors (Lin and Hsu, 2003b), muscle compositions (Lin *et al.*, 2011b), ATP related compounds (Lin *et al.*, 2011b), fiber diameter and area (Lin and Hsu, 2003a; Lin *et al.*, 2011b), certain muscle physical properties (Lin and Hsu, 2002; Lin *et al.*, 2011b), taste panel scores (Lin *et al.*, 2011b), and bone traits (Lin and Hsu, 2003a; Chen *et al.*, 2006a, b; Lin et al, 2012). The effects of castration, androgens treatment or testosterone deficiency on blood traits have been reported in other studies (Chen *et al.*, 2006a, b; Lin *et al.*, 2012; Antunes *et al.*, 2019), but these reports are inconsistent and the main focus is related to the blood parameters and on bone and lipid metabolism. However, these studies do not show other blood characteristics. PCV value measures the percentage composition of blood cells relative to other contents. The author further explained that PCV is very useful in assessing normal blood levels in animals (Augustine et al, 2020). There are limited studies comparing capons, slips or sham chickens in blood PCV, plasma pH and certain blood parameters. The aim of the study is to examine the blood PCV, plasma blood biochemical characteristics in the caponization situations.

Materials and methods

I. Experimental design and animal feeding

Healthy male Taiwan native chicken cockerels (LRI native chicken Taishi meat No. 13.) bred by the Taiwan Livestock Research Institute, were caponized or sham operated at the 10th week of age and were reared in an open-sided broiler house with 22 chickens in each pen (200 cm × 450 cm) for a 4-week adaptation period. Twenty- two male (sham), 22 slips, and 22 caponized (capon, prominent degenerated comb) chickens were selected at the 14^{th} week of age for a 14-week feeding experiment. From the 10^{th} to 18^{th} weeks of age, chickens were fed 19% crude protein and 3,000 kcal/kg metabolizable energy grower rations. From the 19^{th} to 28^{th} weeks, the chickens were fed 17% crude protein and 2,800 kcal/kg metabolizable energy finisher rations. The chickens received a daily photoperiod of 23 h light and 1 h dark. Feed and water were provided ad libitum (Lin and Hsu, 2003a). The experimental procedures involving animals were performed in accordance with the COA-LRI Guide for Care and Use of Laboratory Animals.

II. Testectomy

The testectomy procedure was performed according to Lin and Hsu (2002). Male chickens were restrained and restricted to feed and water for 24 h before the surgical operation. The incision site was sterilized with iodine-alcohol. A 1-cm lateral incision was made from the last rib. The testes were then removed. Iodine-alcohol was applied again to the incision site for disinfection.

III. Capon and slip distinguished

Capons and slips were distinguished according to Lin and Hsu (2003a). Although, chicken cockerels were caponized in the same way, but some chicken castrations were incomplete, leading to a few testicles remaining in the abdominal cavity. Relics of testicle can be regrown several weeks later, resulting in these chickens redeveloping a comb and wattle, with which caponized chickens can be divided into capon and slip groups. The comb and wattle color were bright red. The size change of the slip was significant, whereas the capons appeared to maintain an atrophy status.

IV. Sample collection and analysis

Twenty chickens in each group were bled between the 14 and 28 weeks of age at 2-week intervals. After 12 h of feed deprivation, the blood samples were collected from the brachial vein using a syringe pre-rinsed with a solution 0.15 M NaCl containing 1,000 IU/mL of heparin-Li. Then, samples were placed into a tube containing 50 μL of a 1,000 IU/mL heparin-Li solution per milliliter of blood. The blood samples were kept on ice, centrifuged (1,500 × *g* for 30

min) at 5℃ and the recovered plasma was placed into three vessels. One of these vessel samples were held at 0 ~ 4℃ for determining plasma ion contents. The remaining vessels were frozen at -20℃ as plasma for other blood parameters analysis. PCV (packed cell volume) was measured by centrifuging, at 13,362 × *g* for 5 minutes (Kubota KN70, Japan). The plasma sodium, potassium and chloride concentration were analyzed using a kit (Bayer, UK) and automatic analyzer (634 ISE $Na^+/K^+/Cl^-$ Analyzer, Ciba Corning, England) within 72 h of blood sampling. The plasma pH and ionized calcium concentration were determined using a kit (Bayer, UK) and automatic analyzer (644 ISE Ca^{2+}/pH Analyzer, Ciba Corning, England). The plasma sodium, potassium and chloride concentration were analyzed using a kit (Bayer, UK) and automatic analyzer (634 ISE $Na^+/K^+/Cl^-$ Analyzer, Ciba Corning, England) within 72 h of blood sampling. Assays for the activities of plasma creatine kinase, alkaline phosphatase and concentrations of plasma total calcium, inorganic phosphorus, magnesium, total protein, albumin, globulin, uric acid, urea nitrogen, triglyceride, total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), creatinine and lactic acid were determined with different kits (Wako, Japan) and automatic analyzers (Hitachi 7050, Japan). The total hydroxyproline and free hydroxyproline concentrations in plasma were measured according to the method of Bannister and Burns (1970). Determination of the concentrations of plasma testosterone, calcitonin and parathyroid hormone were carried out with an ELISA microtiter reader (Mrx Dynex Technologies, USA), using different ELISA kits (Neogen Testosterone ELISA kit, Active Calcitonin ELISA kit, DSL-10-7700 and Active Parathyroid hormone ELISA kit, DSL-10-8000).

V. Statistical analysis

Analysis of variance among treatment groups (sham, slips, and capons) were calculated using the General Linear Models (GLM) procedure of SAS (SAS Institute Inc., 2006). The physiological values of different experimental animals at the same age and the physiological values of the same experimental animals at different ages are statistically compared. When significant differences were detected ($P < 0.05$), means were used Least Squares Means (LSMeans).

Results and discussion

I. Blood PCV, plasma pH, and concentrations of plasma Na^+, K^+ and Cl^-

The blood PCV, plasma pH, and concentrations of plasma sodium, potassium, and chloride data are summarized in Table 1. Results showed that the sham group had the highest ($P < 0.05$) PCV at the 14 weeks of age (after 4 weeks of caponized treatment), followed by slips and capons. The PCV in sham and slips increased significantly with the advance of age, and the peak occurred at the 20^{th} and 24^{th} weeks of age ($P < 0.05$). This is in agreement with the finding of Lin and Hsu (2011a), who reported male chickens had significantly higher PCV than those of capons. Peh *et al.* (2000) found similar findings that male chickens had significantly higher PCV than that of female chickens. In addition, Griggs *et al.* (1989) also indicated that groups administered testosterone had greater PCV than those of controls. However, Lin *et al.* (2012) also indicated that the plasma testosterone concentration was significantly lower in capons at the 12th week of age than that of the intact males. In addition, Lin and Hsu (2003a) found that intact chickens had the highest concentration of testosterone followed by slips and capons. Accordingly, the blood PCV in male chickens and slips may have been caused by the effect of higher androgen increasing the bodily erythropoiesis and greater PCV than that of capons as suggested by Lin and Hsu (2011a).

The sham group had the highest plasma pH at the 16^{th} week of age followed by slips and capons ($P < 0.05$), which was consistent with the results of Lin and Hsu (2011a), who showed capons had lower plasma pH than male birds. However, Peh *et al.* (2000) showed that there were no significant differences between sexes in their serum pH. The results for plasma pH in this study were inconsistent with these results. Reasons of capons with lower plasma pH are presently unclear. It may be due to a reduced plasma testosterone concentration. In animals exposed to androgens, there is an alteration of fiber type profiles and muscle metabolism. Castration causes an increase in white fiber numbers, muscle glycogen contents and glycolytic enzymes activity, resulting in enhanced pyruvate or lactate deposition and reduced plasma pH, as shown by Judge *et al.* (1988).

The results of this study for the concentration of plasma sodium were inconsistent at different weeks of age among sham, slips and capons. However, slips had significantly lower mean plasma sodium concentrations than sham and

capons ($P < 0.05$), but there was no significant difference between sham and capons. Similarly, Peh *et al.* (2000) and Lin and Hsu (2011a) have reported that no effects on plasma sodium concentration between the male and female chickens or capons were found.

The capons had the highest concentration of plasma potassium at the 16th week of age, followed by slips and sham ($P < 0.05$). These results agree with Lin and Hsu (2011a), who indicated that male chickens had a lower concentration of plasma potassium than capons. Similarly, Peh *et al.* (2000) also found that female Silkie bantams had a higher concentration of plasma potassium than that of male birds. The testosterone is anabolic in normal adult subjects and is considerable evidence for positive nitrogen, potassium, and phosphorus balance. An increase in muscle mass is reflected by increasing total body potassium content (Griggs *et al.*, 1989). Therefore, the observed higher plasma potassium values for capons in this study were associated with a lower plasma testosterone concentration, which may have been due to decreased muscle protein synthesis, as resulted by Lin and Hsu (2013).

The results of the present study for the concentration of plasma chloride were inconsistent at different weeks of age among sham, slips and capons. However, slips had significantly higher mean than that of the sham and capons ($P < 0.05$), but the plasma chloride concentration did not significantly differ between sham and capons. Lin and Hsu (2011a) found no difference in the concentrations of plasma chloride between capon and male chicken. In contrast, Peh *et al.* (2000) indicated plasma chloride concentrations were higher in female Silkie bantams than that in male birds.

II. Concentrations of plasma ionized calcium, total calcium, inorganic phosphorus, magnesium, and activity of plasma alkaline phosphatase

The concentrations of plasma ionized calcium, total calcium, inorganic phosphorus, magnesium, and activity of plasma alkaline phosphatase results in this experiment are presented in Table 2. The capons had the highest concentrations of plasma ionized calcium at the 14th week of age ($P < 0.05$), followed by slips and sham. However, the concentrations of plasma total calcium were not affected by the treatments. Further, the concentrations of plasma total calcium in sham, slips and capons peaked at the 18th week of age, and declined at the 22th week of age. Lin and Hsu (2003a), Chen *et al.* (2007), and Lin *et al.* (2012) had the same results, attributing this difference to increased bone calcium loss by the capons or slips that favored bone loss over bone formation. In contrast, Peh *et al.* (2000) also found that male Silkie bantams had significantly higher concentrations of serum ionized calcium than female chickens. Chen *et al.* (2006a) showed that caponization increased the blood total calcium concentration. Moreover, Mauras *et al.* (1999) also demonstrated that orchidectomized rats or hypogonadism men showed no serum ionized calcium concentration change. In the present study, capons have a higher plasma ionized calcium concentration, associated with higher plasma calcitonin concentration, as shown by Stepan and Lachman (1989). These results showed the plasma calcitonin concentrations in the capons were significantly higher than in the sham (Table 5). These results support the current findings that ionized calcium showed a better response than total calcium in terms of the analyses on blood calcium concentration.

The capons had the highest ($P < 0.05$) concentrations of plasma inorganic phosphorus at the 14th week of age (caponized treatment after 4 weeks), followed by slips and sham. The concentrations of plasma inorganic phosphorus in sham, slips and capons reduced significantly with the advance of age ($P < 0.05$), which agreed with Lin and Hsu (2003a), Chen *et al.* (2006a), and Lin *et al.* (2012). However, Mauras *et al.* (1999) reported the reverse results. Orchidectomized rats or hypogonadism men had significantly lower serum phosphorus concentrations. On the other hand, Bogin (1992) indicated that hypoparathyroidism causes an increment in the plasma phosphorus concentration. In addition, Vanderchuersen and Bouillion (1995) found that androgens increased marrow cell or osteoblast sensitivity to the parathyroid hormone. Besides, the increased concentrations of plasma inorganic phosphorus in capons are probably due to reduced concentrations of plasma testosterone, leading to reduction in marrow cell or osteoblast sensitivity to the parathyroid hormone.

The concentrations of plasma magnesium did not significantly differ among treated groups, but the sham, slips and capons before the 16th week of age had a lower plasma magnesium concentration than after the 18th week of age, which was consistent with the results of Lin and Hsu (2003a) and Lin *et al.* (2012). Plasma alkaline phosphatase activity was as high as in capons over the slips and sham, and as expected showed a significant difference at the 18th and 28th weeks of age. The results are in agreement with previous reports (Chen *et al.*, 2007; Lin *et al.*, 2012). However, the increased blood

alkaline phosphatase activity damages bone cells and their cell numbers increase in bone remodeling (Bogin, 1992). In general, castration causes an increase in bone calcium loss (Lin and Hsu, 2003a; Chen *et al.*, 2006b; Lin *et al.*, 2012). Phosphate calcium and carbonate calcium account for the largest part of the cortical bone. In this study, it is reasonable to expect capons to have a higher plasma ionized calcium, inorganic phosphorus and alkaline phosphatase concentration, associated with lower plasma testosterone concentrations, as discussed by Lin *et al.* (2012).

III. Activity of plasma creatine kinase and concentrations of plasma creatinine, uric acid, triglyceride, total cholesterol, and total protein

Table 3 shows the activity of plasma creatine kinase and concentrations of plasma creatinine, uric acid, triglyceride, total cholesterol, and total protein results. Plasma creatine kinase activity in capons was higher than that in the sham group at 16 weeks of age, and showed a significant difference at the 20^{th} week of age and mean activity of age. The results in this study agreed with those of Lin and Hsu (2011a), who found that caponization increased blood creatine kinase activity. In contrast, Griggs *et al.* (1989) found a significant increase in creatine kinase activity during testosterone administration in men. Blood creatine kinase activity, indicating striated muscle and heart muscle healthy state, lean mass and psychological state, has been reported in another study (Griggs *et al.*, 1989; Bogin, 1992). The capons showed higher activities of plasma creatine kinase are presently unclear, but it is probably due to castration leading to reduced concentrations of plasma testosterone and an altered temperament, increasing timidity and sensitivity, as suggested by Wang (2001). Bogin (1992) demonstrated that the blood creatine kinase activity increased, which reflected animals under stress.

Plasma creatinine concentrations in the sham group were higher than those in the capons between the 14^{th} and 28^{th} weeks of age, showing significant differences of mean concentration at the 16^{th}, 18^{th}, 24^{th} and 26^{th} weeks. Besides, the concentrations of plasma creatinine in the sham group reduced significantly with the increment of age ($P < 0.05$). Similarly, Griggs *et al.* (1989) showed that there was significant increment in serum creatinine concentration during testosterone administration. However, increases in muscle mass as reflected by increasing urinary creatinine excretion content and serum creatinine concentration have been shown in other studies (Bogin, 1992). The observed lower plasma creatinine concentrations for capons in this study are associated with lower plasma testosterone concentration, which may be due to decreased muscle protein synthesis (Lin and Hsu, 2013).

The capons had significantly higher concentrations of plasma uric acid at the 14^{th} week of age ($P < 0.05$), whereas the capons had significantly lower concentrations of plasma uric acid than the sham group after 18 weeks of age ($P < 0.05$). Lin and Hsu (2011a) also had similar results. Accordingly, it seems reasonable to conclude the observed lower plasma uric acid concentrations for capons in this study are associated with an improved feed conversion after 18 weeks of age, which may be due to decreased plasma testosterone concentration leading to less aggression and sexual (mount-bite) behavior, as has been suggested by Wang (2001) and Lin and Hsu (2002).

The capons had the highest concentration of plasma total cholesterol at the 16^{th} week of age ($P < 0.05$), followed by slips and sham, which were consistent with the results of Chen *et al.* (2005) and Lin and Hsu (2011a). In contrast, Griggs *et al.* (1989) showed that there was no significant change in serum total cholesterol concentration during testosterone administration. Further, the capons or slips had higher concentrations of plasma triglyceride at the 16^{th} week of age, and a significant difference at the 16^{th}, 18^{th}, 26^{th} and 28^{th} week of age and mean concentration of age. Lin and Hsu (2011a) also had similar results, but the reverse was shown by the results of Griggs *et al.* (1989) with no significant change in serum triglyceride concentration during testosterone administration. Moreover, the reduced plasma total cholesterol and triglyceride concentration in the sham may be attributed to the effects of androgen decrease in lipogenic enzyme activity (Chen *et al.*, 2005). On the other hand, the enhanced plasma total cholesterol and triglyceride concentrations in the capons and slips are likely due to castration, which resulted in less activity (Wang, 2001), higher intake of feed (Lin and Hsu, 2002), and a higher fat content (Lin *et al.*, 2011b). Compared with other groups, the sham group had significantly lower concentrations of plasma total protein at the 14^{th} weeks of age ($P < 0.05$). These results are in agreement with the findings of Lin and Hsu (2011a), who reported intact birds were lower in plasma total protein concentration than capons and slips. In contrast, Peh *et al.* (2000) found no significant differences between sexes in serum total protein concentration. Therefore, it is reasonable to expect the capons had high concentrations of plasma total protein associated with higher plasma albumin and globulin concentration (Table 4).

IV. Concentrations of plasma albumin, globulin, urea nitrogen, total hydroxyproline, free hydroxyproline, LDL, HDL, and lactic acid

The concentrations of plasma albumin, globulin, urea nitrogen, total hydroxyproline, free hydroxyproline, LDL, HDL, and lactic acid in this study are displayed in Table 4. Compared with the sham group, slips and capons had significantly lower concentrations of plasma albumin and globulin at the 28th week of age ($P < 0.05$). However, caponized treatment had no effects on the concentration of plasma urea nitrogen. Lin and Hsu (2011a) had similar results, but in contrast, Vaelimaeki *et al.* (1999) demonstrated that concentrations of serum testosterone decreased, resulting in a concomitant drop in serum albumin. Preston *et al.* (1995) indicated that the anabolic steroids and growth hormone-releasing factors were additive, decreasing plasma urea nitrogen concentration in feedlot steers. The results of the concentration of plasma urea nitrogen in this study are not completely consistent with these reports. The reasons for such discrepancy could be due to the different kinds of animal chosen. Moreover, the reduced plasma globulin concentration in the sham group is probably due to increased blood testosterone concentration, leading to inhibited immune organs development and immune response, as discussed by Vojtiskova *et al.* (1976) and Fennel and Scanes (1992). On the other hand, capons have high concentrations of plasma albumin, which is associated with increased lipid synthesis (higher plasma triglyceride and total cholesterol concentration), and causes increased albumin in the blood for transport lipid.

The capons and slips showed significantly higher concentrations of plasma LDL and HDL than those of the sham group at the 28th week of age ($P < 0.05$), which was consistent with the results of study of Chen *et al.* (2005) and Lin and Hsu (2011a). Thus, capons and slips had high concentrations of plasma LDL and HDL, which was associated with higher plasma total cholesterol concentration. Compared with the sham group, capons and slips had a significantly lower concentration of plasma total hydroxyproline ($P < 0.05$), but the plasma free hydroxyproline concentration was unaffected among the sham, slips and capons at the 28th week of age. These results agree with the report of Lin and Hsu (2011a), who indicated that plasma total hydroxyproline concentrations were higher in capons than in intact chickens, but the plasma free hydroxyproline concentration was unaffected by the caponization treatment. Similarly, Gerrard *et al.* (1987) found the serum hydroxyproline and testosterone concentrations in bulls were higher than that in steers. A significant increase in connective tissue content during testosterone administration in men has been demonstrated (Griggs *et al.*, 1989). Moreover, Stepan and Lachman (1989) indicated increased urinary hydroxyproline excretion in castration males. However, no treatment differences were associated with concentrations of plasma lactic acid among the sham, slips and capons. Lin and Hsu (2011a) showed similar results.

V. Concentrations of plasma testosterone, parathyroid hormone and calcitonin

Some blood hormone parameters data are summarized in Table 5. The sham group had the highest concentrations of plasma testosterone at the 28th week of age ($P < 0.05$), followed by slips and capons, which was consistent with the results of Lin and Hsu (2003a) and Chen *et al.* (2005). In addition, Mashaly (1984) reported that 3-week-old cockerels subjected to orchiectomy treatment after 2 weeks caused a reduction in the serum testosterone concentration, but the serum dihydrotestosterone concentration after 12 weeks orchiectomy treatment was also reduced. Moreover, Lin *et al.* (2012) also demonstrated 8-week-old cockerels at orchiectomy treatment after 4 weeks caused a reduction in the serum testosterone concentration.

The plasma parathyroid hormone concentration could be as much as 11.5% in capons over the sham at the 28th week of age. However, this is not enough to conclude that there is a resulting difference among the treated groups. Lin and Hsu (2011a) also had similar results. Similarly, Mauras *et al.* (1999) showed that hypogonadism men showed unchanged serum parathyroid hormone concentration between the baseline and 10 weeks later. In normal physiology, parathyroid hormone secretion over the basal level occurred in response to decreased extracellular ionized calcium concentration, resulting in a close inverse relationship between the blood parathyroid hormone and calcium concentration (Marcus, 1989). Thus, it is reasonable to expect capons have a higher plasma parathyroid hormone concentration, which is associated with higher ionized calcium concentration. Vanderchuersen and Bouillion (1995) found that androgens could have increased marrow cell or osteoblast sensitivity to the parathyroid hormone. The parathyroid hormone has a wide range of biological actions primarily related to the prevention of hypocalcemia. Kao *et al.* (1992) showed that these reactions included enhancement of bone reabsorption, stimulation of distal renal tubular calcium reabsorption, inhibition of proximal renal tubular phosphate reabsorption, and stimulation of renal 1 α -hydroxylation of 25-OH vitamin D.

Compared with the sham, capon and slip groups had a significantly higher concentration of plasma calcitonin at the 28th week of age ($P < 0.05$). These results agree with the results of Stepan and Lachman (1989) and Lin and Hsu (2011a), who stated castrated men or cockerels showed an increase in blood calcitonin concentration. In contrast, Mauras *et al.* (1999) showed hypogonadism men did not have altered the serum calcitonin concentration between the baseline and 10 weeks later. However, Copp (1992) found that the major action of calcitonin was to lower plasma calcium concentration. Relatively small increments in extracellular calcium concentration had been indicated to stimulate calcitonin secretion. Calcitonin secretion had been also regulated by gastrointestinal peptide, estrogen, and vitamin D.

The gonads are related to the accumulation of calcium in the bones. After the testicle is castrated, the calcium dissolving power of the bone increases, which affects the calcium metabolism. This is the feedback pathway of calcium after the testicle is removed. Calcitonin apparently acts by inhibiting osteoclast activity, resulting in decreased mobilization of calcium from bones. Thus, the results from the observed higher plasma calcitonin concentration in capons and slips are associated with higher plasma ionized calcium concentration. This study discovered the caponization of male chickens could reflect blood content and body states. Therefore, the study would point out the influence of muscle protein and lipid synthesis, connective tissues growth and bone formation on male chickens.

Conclusion

The test studied the effect of age and caponization on blood biochemical parameters of male native chickens. These findings of blood biochemical parameters can directly reflect body states in this study. The caponization caused a significant decrease in blood PCV, plasma pH, and some characteristics after 4 to 6 weeks post treatment, which showed androgen could directly influence erythropoiesis, muscle protein and lipid synthesis, connective tissues growth and bone formation in male native chickens.

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Table 1. Effect of age on the blood PCV, plasma pH, sodium, potassium, and chloride of native chickens

Items	Weeks of age									S.E.
	14	16	18	20	22	24	26	28	Mean	
PCV, %										
Sham (n = 20)	33.4^{d,x}	35.5^{c,x}	37.9^{b,x}	40.3^{a,x}	40.1^{a,x}	40.6^{a,x}	41.4^{a,x}	41.6^{a,x}	38.9^{x}	0.23
Slip (n = 20)	30.1^{c,y}	30.8^{bc,y}	31.2^{bc,y}	33.6^{ab,y}	34.2^{a,y}	32.9^{abc,y}	35.4^{a,y}	34.8^{a,y}	32.9^{y}	0.33
Capon (n = 20)	28.2^{b,y}	29.5^{ab,y}	28.7^{ab,z}	30.4^{a,z}	29.9^{ab,z}	29.1^{ab,z}	30.4^{a,z}	29.0^{ab,z}	29.4^{z}	0.19
S.E.	0.29	0.30	0.37	0.39	0.44	0.46	0.52	0.46	0.17	
pH										
Sham (n = 20)	7.64^{ab}	7.66^{a,x}	7.65^{ab,x}	7.51^{d,x}	7.66^{a,x}	7.60^{bc}	7.56^{cd}	7.67^{a,x}	7.62^{x}	0.006
Slip (n = 20)	7.61^{a}	7.59^{ab,y}	7.51^{c,y}	7.45^{d,y}	7.65^{bc,x}	7.57^{ab}	7.55^{bc}	7.60^{bc,y}	7.57^{y}	0.006
Capon (n = 20)	7.61^{ab}	7.55^{cd,y}	7.52^{d,y}	7.44^{e,y}	7.55^{a,y}	7.57^{bc}	7.54^{cd}	7.55^{bc,y}	7.54^{z}	0.006
S.E.	0.010	0.011	0.009	0.008	0.008	0.009	0.007	0.011	0.004	
Na^+, mmol/L										
Sham (n = 20)	148.6^{cd}	150.0^{cd}	148.1^{d}	153.4^{b}	150.6^{c,y}	156.2^{a,x}	153.7^{b,x}	150.4^{c,x}	151.4^{x}	0.24
Slip (n = 20)	150.1^{bc}	150.4^{bc}	147.6^{d}	152.9^{a}	150.6^{bc,y}	151.2^{ab,y}	151.3^{ab,y}	148.6^{cd,y}	150.3^{y}	0.24
Capon (n = 20)	149.0^{cd}	150.9^{bc}	149.5^{cd}	152.1^{ab}	153.9^{a,x}	153.0^{ab,y}	152.9^{ab,xy}	148.3^{d,y}	151.2^{x}	0.24
S.E.	0.43	0.48	0.45	0.39	0.42	0.55	0.36	0.46	0.18	
K^+, mmol/L										
Sham (n = 20)	4.45^{a}	3.85^{bc,y}	3.57^{cd,y}	4.57^{a,y}	4.04^{b,y}	3.40^{d,z}	3.57^{cd,y}	3.82^{bc,y}	3.91^{z}	0.041
Slip (n = 20)	4.36^{bc}	4.44^{ab,x}	4.29^{bc,x}	4.74^{a,xy}	4.47^{ab,xy}	4.05^{cd,y}	3.74^{d,y}	3.88^{d,xy}	4.25^{y}	0.041
Capon (n = 20)	4.81^{ab}	4.51^{bc,x}	4.42^{cd,x}	5.11^{a,x}	4.73^{bc,x}	4.51^{bc,x}	4.06^{e,x}	4.13^{de,x}	4.55^{x}	0.039
S.E.	0.048	0.052	0.084	0.079	0.061	0.059	0.067	0.056	0.028	
Cl^-, mmol/L										
Sham (n = 20)	110.4^{de,x}	109.0^{e}	114.0^{ab}	115.5^{a}	111.6^{cd,y}	112.7^{bc,y}	113.4^{bc}	109.1^{e}	112.0^{y}	0.22
Slip (n = 20)	110.9^{c,x}	110.2^{c}	113.7^{b}	115.2^{ab}	114.4^{ab,x}	116.7^{a,x}	114.2^{b}	107.4^{d}	112.8^{x}	0.20
Capon (n = 20)	105.8^{d,y}	109.3^{bc}	115.0^{a}	114.7^{a}	115.3^{a,x}	113.2^{a,y}	114.2^{a}	108.0^{c}	111.9^{y}	0.19
S.E.	0.37	0.36	0.41	0.28	0.26	0.40	0.25	0.51	0.18	

$^{a, b, c, d, e}$ Means within the same row without the same superscripts differ ($P < 0.05$).

$^{x, y, z}$ Means within the same column without the same superscripts differ ($P < 0.05$).

Table 2. Effect of age on the concentrations of plasma ionized calcium, total calcium, inorganic phosphorus, magnesium, and activity of alkaline phosphatase of native chickens

Items	Weeks of age									
	14	16	18	20	22	24	26	28	Mean	S.E.
Ca^{2+}, mmol/L										
Sham (n = 20)	$1.13^{d,y}$	$1.14^{d,y}$	$1.27^{y,c}$	$1.47^{ab,y}$	$1.42^{ab,y}$	$1.41^{b,y}$	$1.40^{b,y}$	$1.49^{a,y}$	1.34^{y}	0.009
Slip (n = 20)	$1.24^{de,x}$	$1.22^{e,x}$	$1.29^{xy,d}$	$1.51^{b,x}$	$1.59^{a,x}$	$1.40^{c,y}$	$1.57^{a,x}$	$1.58^{a,x}$	1.43^{x}	0.007
Capon (n = 20)	$1.26^{e,x}$	$1.24^{e,x}$	$1.35^{x,d}$	$1.51^{c,x}$	$1.62^{ab,x}$	$1.51^{c,x}$	$1.55^{bc,x}$	$1.64^{x,a}$	1.46^{x}	0.010
S.E.	0.011	0.013	0.010	0.007	0.007	0.006	0.011	0.016	0.014	
Total calcium, mg/dL										
Sham (n = 20)	11.45^{a}	11.38^{a}	11.58^{a}	10.96^{ab}	10.56^{bc}	10.28^{bc}	10.08^{c}	10.55^{bc}	10.86	0.234
Slip (n = 20)	11.42^{ab}	11.54^{a}	12.10^{a}	10.69^{bc}	10.34^{c}	10.64^{bc}	10.12^{c}	10.36^{c}	10.90	0.246
Capon (n = 20)	11.38^{ab}	11.97^{a}	12.02^{a}	11.59^{ab}	10.77^{bc}	10.56^{c}	10.27^{c}	10.57^{c}	11.14	0.242
S.E.	0.246	0.286	0.342	0.314	0.272	0.249	0.234	0.194	0.230	
Inorganic phosphorus, mg/dL										
Sham (n = 20)	$5.42^{a,y}$	$5.06^{a,z}$	$4.23^{b,z}$	$3.87^{bc,z}$	$3.55^{c,z}$	$3.57^{c,y}$	$3.28^{c,z}$	$3.51^{c,y}$	4.06^{z}	0.062
Slip (n = 20)	$5.82^{a,y}$	$5.81^{a,y}$	$5.04^{b,y}$	$4.69^{bc,y}$	$4.43^{cd,y}$	$4.06^{de,xy}$	$3.67^{ef,y}$	$3.48^{f,y}$	4.63^{y}	0.077
Capon (n = 20)	$6.18^{a,x}$	$6.27^{a,x}$	$5.89^{a,x}$	$5.35^{bc,x}$	$4.93^{c,x}$	$4.44^{d,x}$	$4.07^{d,x}$	$4.33^{d,x}$	5.18^{x}	0.057
S.E.	0.114	0.094	0.092	0.111	0.089	0.103	0.084	0.072	0.059	
Magnesium, mg/dL										
Sham (n = 20)	2.04^{b}	2.03^{b}	2.36^{a}	2.33^{a}	2.20^{ab}	2.17^{ab}	2.18^{ab}	2.38^{a}	2.21	0.073
Slip (n = 20)	2.02^{b}	2.01^{b}	2.24^{ab}	2.18^{ab}	2.24^{ab}	2.28^{ab}	2.44^{a}	2.38^{a}	2.22	0.063
Capon (n = 20)	2.03^{b}	2.00^{b}	2.17^{ab}	2.14^{ab}	2.35^{a}	2.32^{a}	2.21^{ab}	2.44^{a}	2.21	0.060
S.E.	0.111	0.108	0.208	0.068	0.075	0.092	0.067	0.068	0.142	
Alkaline phosphatase, U/L										
Sham (n = 20)	$1,386.4^{ab}$	$1,348.6^{ab}$	$1,424.6^{a,y}$	$1,277.2^{ab}$	$1,120.6^{ab}$	953.2^{ab}	784.2^{ab}	$363.8^{b,y}$	$1,082.3^{y}$	313.48
Slip (n = 20)	$1,936.6^{c}$	$1,989.2^{ab}$	$2,113.7^{a,xy}$	$1,548.3^{ab}$	$1,184.4^{ab}$	$1,065.7^{ab}$	527.5^{ab}	$303.6^{b,y}$	$1,333.6^{xy}$	432.13
Capon (n = 20)	$2,107.2^{abc}$	$2,353.4^{ab}$	$2,599.7^{a,x}$	$1,896.3^{abc}$	$1,202.6^{abc}$	$1,052.4^{abc}$	916.3^{bc}	$467.5^{c,x}$	$1,574.4^{x}$	508.64
S.E.	531.78	543.06	533.78	381.46	183.48	188.78	184.25	45.69	150.44	

[a, b, c, d, e, f] Means within the same row without the same superscripts differ ($P < 0.05$).

[x, y, z] Means within the same column without the same superscripts differ ($P < 0.05$).

Table 3. Effect of age on the activity of plasma creatine kinase, plasma creatinine, uric acid, triglyceride, total cholesterol, and total protein of native chickens

Items	Weeks of age									
	14	16	18	20	22	24	26	28	Mean	S.E.
Creatine kinase, U/L										
Sham (n = 20)	173.7^{ab}	199.6^{a}	167.3^{ab}	171.4^{ab,y}	145.6^{b}	161.5^{ab}	139.2^{b}	202.0^{a}	170.0^{y}	4.30
Slip (n= 20)	165.4^{bc}	204.9^{ab}	158.5^{c}	154.0^{c,y}	152.0^{c}	159.6^{c}	164.1^{bc}	225.2^{a}	173.0^{y}	5.05
Capon (n = 20)	159.9^{ab}	211.4^{ab}	173.7^{ab}	212.4^{ab,x}	175.9^{ab}	200.8^{ab}	154.6^{b}	215.6^{a}	188.0^{x}	5.86
S.E.	8.23	7.46	6.85	8.00	7.85	9.90	9.87	12.82	3.26	
Creatinine, mg/dL										
Sham (n = 20)	0.470^{a,x}	0.450^{ab,x}	0.440^{ab,x}	0.430^{ab}	0.420^{ab}	0.410^{ab,x}	0.410^{ab,x}	0.400^{b}	0.429^{x}	0.0057
Slip (n= 20)	0.420^{abc,y}	0.460^{a,x}	0.440^{ab,x}	0.410^{abc}	0.430^{abc}	0.370^{c,xy}	0.410^{abc,x}	0.400^{bc}	0.414^{xy}	0.0060
Capon (n = 20)	0.450^{ab,xy}	0.410^{bcd,y}	0.400^{bcd,y}	0.420^{bc}	0.400^{bcd}	0.356^{d,y}	0.370^{cd,y}	0.390^{cd}	0.399^{y}	0.0061
S.E.	0.0012	0.0098	0.0096	0.0011	0.0013	0.0097	0.0098	0.0014	0.0038	
Uric acid, mg/dL										
Sham (n = 20)	3.24^{c,y}	4.42^{c}	6.72^{a,x}	6.28^{ab,x}	7.73^{ac,x}	7.56^{a,x}	7.56^{a,x}	6.46^{ab,x}	6.25^{x}	0.183
Slip (n = 20)	3.76^{b,xy}	4.31^{ab}	5.49^{ab,y}	4.27^{ab,y}	4.30^{ab,y}	4.59^{ab,y}	5.45^{ab,y}	5.92^{a,xy}	4.76^{y}	0.208
Capon (n = 20)	4.21^{x}	4.03	3.51^{z}	3.88^{y}	4.09^{y}	3.68^{z}	4.64^{z}	4.78^{y}	4.10^{y}	0.206
S.E.	0.231	0.218	0.410	0.321	0.421	0.429	0.441	0.381	0.169	
Total cholesterol, mg/dL										
Sham (n = 20)	113.0^{a}	98.9^{abc,y}	106.7^{ab,y}	102.7^{ab,y}	87.6^{cd,z}	94.8^{bcd,y}	82.6^{d,z}	84.9^{cd,z}	96.4^{z}	1.49
Slip (n = 20)	123.4^{a}	109.6^{b,xy}	102.6^{bcd,y}	107.2^{bc,y}	105.9^{bcd,y}	109.8^{b,y}	94.3^{d,y}	97.2^{cd,y}	106.3^{y}	1.33
Capon (n= 20)	118.7	116.7^{x}	122.7^{x}	126.9^{x}	123.6^{x}	129.2^{b,x}	127.6^{x}	128.1^{x}	124.2^{x}	1.23
S.E.	2.58	2.36	2.54	2.80	2.85	3.49	2.26	2.20	0.99	
Triglyceride, mg/dL										
Sham (n = 20)	22.2	18.4^{y}	21.1^{y}	20.7	22.7	22.9	23.2^{y}	24.1^{y}	21.6^{y}	0.85
Slip (n = 20)	22.8^{c}	25.6^{bc,x}	29.3^{b,x}	25.2^{bc}	24.4^{bc}	26.5^{bc}	28.3^{b,x}	33.3^{a,y}	26.9^{x}	0.63
Capon (n = 20)	23.2^{b}	26.9^{b,x}	24.5^{b,xy}	26.8^{b}	27.7^{b}	27.1^{b}	30.5^{b,x}	41.2^{a,x}	28.5^{x}	0.96
S.E.	1.54	1.57	1.56	1.39	1.26	1.24	1.58	1.67	0.72	
Total protein, g/dL										
Sham (n = 20)	3.80^{c,y}	3.93^{bc,y}	4.07^{abc,y}	4.38^{ab,y}	4.53^{a}	4.30^{ab,y}	4.40^{ab,y}	4.22^{abc,y}	4.20^{y}	0.048
Slip (n= 20)	4.04^{c,xy}	4.22^{bc,xy}	4.14^{c,xy}	4.51^{ab,xy}	4.48^{ab}	4.65^{a,xy}	4.77^{a,x}	4.59^{a,xy}	4.42^{x}	0.035
Capon (n = 20)	4.20^{c,x}	4.33^{bc,x}	4.46^{bc,x}	4.68^{abc,x}	4.73^{abc}	4.73^{abc,x}	5.04^{a,x}	4.86^{ab,x}	4.63^{x}	0.057
S.E.	0.069	0.071	0.088	0.068	0.073	0.089	0.072	0.181	0.033	

$^{a, b, c, d}$ Means within the same row without the same superscripts differ ($P < 0.05$).

$^{x, y, z}$ Means within the same column without the same superscripts differ ($P < 0.05$).

Table 4. Comparison on the plasma albumin, globulin, urea nitrogen, lactic acid, total hydroxyproline, free hydroxyproline, low-density lipoprotein, and high-density lipoprotein concentration in Taiwanese native chickens at 28 weeks of age

Items	Sham (n = 20)	Slips (n = 20)	Capons (n = 20)	S.E.	P
Albumin, g/dL	2.8[b]	3.3[a]	3.5[a]	0.16	< 0.05
Globulin, g/dL	1.8[b]	2.1[a]	2.2[a]	0.07	< 0.05
Urea nitrogen, mg/dL	3.3	3.1	3.2	0.39	> 0.05
Low-density lipoprotein, mg/dL	31.8[b]	41.4[a]	42.6[a]	2.64	< 0.01
High-density lipoprotein, mg/dL	58.4[b]	88.2[a]	91.7[a]	3.93	< 0.01
Total hydroxyproline, μg/mL	11.3[a]	9.5[b]	8.8[b]	0.33	< 0.05
Free hydroxyproline, μg/mL	7.2	6.7	6.3	0.25	> 0.05
Lactic acid, mg/dL	72.6	66.5	65.2	6.78	> 0.05

[a, b] Means within the same row without the same superscripts differ ($P < 0.05$).

Table 5. Comparison on the plasma testosterone, parathyroid hormone, and calcitonin concentration in Taiwanese native chickens at 28 weeks of age

Items	Sham (n = 20)	Slips (n = 20)	Capons (n = 20)	S.E.	P
Testosterone, pg/mL	1,484.9[a]	292.9[b]	43.5[c]	15.21	< 0.05
Parathyroid hormone, pg/mL	13.9	14.8	15.5	1.89	> 0.05
Calcitonin, pg/mL	11.0[b]	15.3[a]	16.2[a]	1.04	< 0.05

[a, b, c] Means within the same row without the same superscripts differ ($P < 0.05$).

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去勢對臺灣公土雞血液生理值之影響 (1)

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摘　要

本研究旨在探討年齡對臺灣公土雞、閹公雞及復陽雞 (Slip) 之血液血球容積比 (Packed cell volume, PCV)、血漿 pH 值及血漿生理值之影響。試驗選用畜試土雞臺畜肉十三號公雞，雞隻於 10 週齡去勢，並餵給生長期飼料 (10 － 18 週齡) 及肥育期飼料 (19 － 28 週齡)。於 14 週齡時再將閹公雞處理組，依雞冠有無再度發育，分為閹公雞組與復陽雞組。試驗雞隻經 12 小時禁食後，每隔二週進行個別雞隻採血，每處理組逢機取樣 20 隻。試驗結果顯示，閹公雞 (16 － 28 週齡) 具有最高的血漿無機磷、鉀離子及總膽固醇濃度。閹公雞 (20 － 28 週齡) 具有最低的 PCV、血漿 pH 值；閹公雞於 28 週齡睪固酮濃度最低，復陽雞次之，公雞最高 ($P < 0.05$)。與公雞比較，閹公雞與復陽雞有顯著 ($P < 0.05$) 較高之血漿鈣離子、總蛋白質、白蛋白、球蛋白、三酸甘油酯、低密度脂蛋白、高密度脂蛋白與抑血鈣素濃度，及顯著 ($P < 0.05$) 較低之血漿尿酸濃度。而閹公雞之血漿磷酸激酶和鹼性磷酸酶活性顯著 ($P < 0.05$) 較高，公雞之肌酸酐及總羥脯胺酸顯著 ($P < 0.05$) 較高。血液 PCV 在閹公雞及復陽雞均隨年齡之增加而增加，並分別在 20 及 26 週齡達高峰。而公雞、復陽雞及閹公雞之血漿總鈣濃度在 18 週齡達高峰，22 週齡後降低。公雞、復陽雞及閹公雞之血漿無機磷濃度則隨年齡增加而降低 ($P < 0.05$)。本試驗結果發現，公雞於去勢後 4 至 6 週即會顯著 ($P < 0.05$) 影響 PCV、血漿 pH 值及某些組成，主要與雄性素功能有關，如紅血球生成、蛋白質、脂質、骨骼及結締組織合成。

關鍵詞：年齡、血液生理值、去勢、公雞、睪固酮。

(1) 行政院農業委員會畜產試驗所研究報告第 2661 號。
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飼糧中添加葉用枸杞對白羅曼鵝生長性能及血液生化值之影響 (1)

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摘　要

本研究旨在探討葉用枸杞 (*Lycium chinense* Miller, *LC*M) 新鮮頂芽、葉片或乾燥木質化莖稈粉對白羅曼鵝生長性能及血液生化值之影響。試驗一使用白羅曼母鵝 60 隻，逢機分配至對照組及 3 個處理組，每組 3 欄，每欄 5 隻，於 5 至 12 週齡進行試驗。對照組精料採任飼，3 個處理組之精料給飼量以對照組前 3 至 7 日平均採食量為基準量限飼，額外給予基準量一定比例 5、10 或 15% 之新鮮 *LC*M 頂芽與葉片。試驗結果顯示，3 個處理組新鮮葉用枸杞採食比例為基準精料給飼量之 5.2、9.9 或 14.9% 鮮重基，對照組鵝隻 8 週齡體重顯著高於 3 個處理組，另其 5 － 8 週齡增重亦顯著高於 9.9 及 14.9% 新鮮 *LC*M 給飼量處理組 ($P < 0.05$)。此外，8 及 12 週齡鵝隻血清中之肌酸酐、麩胺草醋酸轉胺酶、麩胺丙酮酸轉胺酶、膽固醇、三酸甘油酯、抗氧化物、過氧化氫酶及超氧化物歧化酶含量於各組間無顯著差異。試驗二使用白羅曼公鵝 60 隻，逢機分配至對照組及 3 個處理組，各組於基礎精料中分別添加 0、1、3 或 5% 乾燥 *LC*M 木質化莖稈粉，取代等比例苜蓿粉，每組 3 欄，每欄 5 隻，試驗期為 3 至 12 週齡。結果顯示，飼糧中添加乾燥 *LC*M 粉對鵝隻總採食量、增重及飼料轉換率均無顯著影響，另血清中之肌酸酐、麩胺草醋酸轉胺酶、麩胺丙酮酸轉胺酶、膽固醇、三酸甘油酯、抗氧化物、過氧化氫酶及超氧化物歧化酶濃度亦無顯著差異。綜上所述，額外給予新鮮葉用枸杞頂芽與葉片至精料給飼量之 14.9% 鮮基重或飼料中添加乾燥葉用枸杞莖稈粉至 5%，對 12 週齡鵝隻生長性能及血液生化值無不良影響，均可做為鵝隻飼糧粗纖維之來源。

關鍵詞：葉用枸杞、生長性能、血液生化值、白羅曼鵝。

緒　言

在歐盟禁用抗生素生長促進劑 (Antibiotic growth promoter, AGP) 後，許多研究已探討植生素是否有替代 AGP 物質之潛能。植生素 (Phytogenics) 是一種存在於植物中的天然化學成分，因其高含量的藥理活性，係一種極具希望之 AGP 替代品 (Grashorn, 2010)。枸杞是茄科 (Solanaceae) 枸杞屬 (*Lycium*) 多年生灌木或小喬木，分為採果型及葉用型二種，果用枸杞品種如寧夏枸杞 (*Lycium barbarum* L.)、新疆枸杞 (*Lycium dasystemum* P.) 等。行政院農業委員會苗栗區農業改良場 (以下簡稱苗改場) 推廣品種係專為採摘嫩葉用之枸杞品系即為葉用枸杞 (*Lycium chinense* Miller, *LC*M)。枸杞為藥食同源植物，全株均可利用作為生藥或保健食品原料，在中醫藥材上占有一定之地位。其莖、葉富含植物性多酚 (Polyphenol)，如類黃酮化合物 (Flavonoids) 及二類配醣體等保健成分，具有抗菌、抗氧化、清除過氧化物陰離子 (Superoxide anion)、抗發炎 (抑制一氧化氮、發炎因子 IL-6 及 TNF-α 等) 等複合性功效 (鍾等，2013；Mocan *et al.*, 2015)，且對於人類腎細胞具有抗發炎的活性 (林及王，2017)。

在抗微生物試驗的研究結果顯示，*LC*M 萃取物對於革蘭氏陽性、陰性菌及真菌皆具有抗菌活性 (Lee *et al.*, 2004; Mocan *et al.*, 2014)。另發現 *LC*M 地上部萃取物可顯著降低小鼠血清中 TNF-α、IL-6 及 IL-1 等發炎因子濃度，可有效改善胃潰瘍反應 (Olatunji *et al.*, 2015)。且枸杞葉汁和枸杞多醣對於快速老化模型小鼠 SAMP8 的老化徵象和學習記憶能力均有改善作用 (苗等，2013)。

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(1) 行政院農業委員會畜產試驗所研究報告第 2662 號。
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*LC*M 之微量元素硒 (Selenium) 含量較一般蔬菜高，約為 0.38 － 1.72 ppm，而常見如洋蔥、菠菜及茼蒿等 12 種蔬菜之平均硒乾重含量僅為 0.295 ppm (劉等，2010)。動物營養上所需硒含量為每公斤飼料 0.04 － 0.1 mg，需求量取決於動物種類和飲食中維生素 E 的含量 (Slekovec and Goessler, 2005)，故富含硒之 *LC*M 有開發做為飼料添加物之潛能。另臺灣常見鄉土蔬菜 (秋葵 *Abelmoschus esculentus* Moench.、九層塔 *Ocimum bullatum*、香椿 *Toona sinensis* M. Roem.、山蘇 *Asplenium antiquum* Makino 及枸杞菜 *LC*M 等共 29 種) 抗氧化物質含量與其抗氧化活性之研究中，發現枸杞葉與紫蘇所含槲皮素 (Quercetin) 量最高 (劉，2013)，槲皮素是一種具有高生物活性的黃酮類化合物，具有廣泛的生物作用，包括抗癌、抗發炎和抗病毒活性以及抗氧化等功能 (Li *et al.*, 2016)。

有關葉用枸杞應用於鵝隻之試驗研究相對稀少，本試驗利用白羅曼鵝探討不同添加量之新鮮及乾燥葉用枸杞對其生長性能及血液生化值之影響，研究結果可供國內養鵝產業使用作為飼料添加物之參考。

材料與方法

I. 試驗動物及管理

試驗用鵝隻為行政院農業委員會畜產試驗所彰化種畜繁殖場 (以下簡稱彰化場) 繁殖之白羅曼鵝。實驗動物管理及使用係經彰化場實驗動物照護及使用委員會核准 (核准編號：畜試彰動字第 10808 號)。鵝隻飼養於非開放式高床鵝舍，飲水任飲，採自然光照，並依肉鵝飼養期分為育雛 (0 至 4 週齡)、 生長 (5 至 8 週齡) 及肥育 (9 至 12 週齡) 期三階段，各階段飼糧營養標準參考 NRC (1994)、許 (2001，2002) 資料進行試驗飼糧設計。白羅曼鵝新鮮葉用枸杞試驗基礎飼糧組成、乾燥葉用枸杞莖稈粉試驗基礎飼糧組成及葉用枸杞一般成分與機能性成分分析詳如表 1 至表 3。

表 1. 白羅曼鵝新鮮葉用枸杞試驗基礎飼糧組成

Table 1. The composition of basal diets for White Romam geese in fresh *LC*M experiment

Ingredients	Grower 5 － 8 weeks	Finisher 9 － 12 weeks
	%	
Yellow corn	62.50	62.50
Soybean meal	14.60	18.40
Alfalfa meal	12.50	13.80
Fish meal	5.10	—
Soybean oil	2.20	2.20
Salt	0.30	0.30
Dicalcium phosphate	1.40	1.40
Limestone, pulverized	0.80	0.80
Choline chloride, 50%	0.10	0.10
L-Lysine	0.10	0.10
Vitamin premix[1]	0.20	0.20
Mineral premix[2]	0.20	0.20
Total	100.00	100.00
Calculated values		
ME, kcal/kg	2,952	2,941
Calcium, %	1.13	0.92
Available phosphorus, %	0.44	0.36
Analysis values		
Crude protein, %	17.41	16.08

[1] Supplied per kilogram of diet: Vitamin A, 10,000 IU; Vitamin D_3, 2,000 IU; Vitamin E; 20 IU; Vitamin B_1, 2 mg; Vitamin B_2, 5 mg; Vitamin B_6, 3 mg; Vitamin B_{12}, 30 μg; Biotin, 200 μg; Vitamin K_3, 3 mg; Niacin, 30 mg; Folic acid, 2 mg and Pantothenic acid, 10 mg.

[2] Supplied per kilogram of diet: Cu, 30 mg; Fe, 200 mg; Zn, 100 mg; Mn, 160 mg; Co, 500 μg; I, 1.7 mg and Se, 300 μg.

表 2.　白羅曼鵝乾燥葉用枸杞粉試驗飼糧組成

Table 2.　The composition of experimental diets for White Romam geese in dry *L*CM powder experiment

Ingredients	Starter 0 — 4 weeks				Grower 5 — 8 weeks				Finisher 9 — 12 weeks			
	0%	1%	3%	5%	0%	1%	3%	5%	0%	1%	3%	5%
	%											
Yellow corn	59.00	59.00	59.00	59.00	60.00	60.00	60.00	60.00	63.00	63.00	63.00	63.00
Soybean meal	24.00	24.00	24.00	24.00	20.50	20.50	20.50	20.50	17.00	17.00	17.00	17.00
*L*CM powder[1]	—	1.00	3.00	5.00	—	1.00	3.00	5.00	—	1.00	3.00	5.00
Alfalfa meal	7.00	6.00	4.00	2.00	14.00	13.00	11.00	9.00	14.50	13.50	11.50	9.50
Fish meal	4.90	4.90	4.90	4.90	—	—	—	—	—	—	—	—
Soybean oil	2.00	2.00	2.00	2.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Dicalcium phosphate	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
Limestone, pulverized	0.90	0.90	0.90	0.90	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Choline chloride, 50 %	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
L-Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin premix[2]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Mineral premix[3]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated values												
Calcium, %	1.10	1.08	1.04	1.00	0.94	0.92	0.89	0.85	0.94	0.92	0.89	0.85
Available phosphorus, %	0.49	0.49	0.49	0.49	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Analysis values												
Crude protein, %	21.42	20.92	19.59	20.19	17.92	17.86	17.45	17.21	14.55	14.48	14.35	14.22

[1] LCM powder: dry powder of *Lycium chinense* Miller.

[2] Supplied per kilogram of diet: Vitamin A, 10,000 IU; Vitamin D_3, 2,000 IU; Vitamin E; 20 IU; Vitamin B_1, 2 mg;Vitamin B_2, 5 mg; Vitamin B_6, 3mg; Vitamin B_{12}, 30 μg; Biotin, 200 μg; Vitamin K_3, 3 mg; Niacin, 30 mg; Folic acid, 2 mg and Pantothenic acid, 10 mg.

[3] Supplied per kilogram of diet: Cu, 30 mg; Fe, 200 mg; Zn, 100 mg; Mn, 160 mg; Co, 500 μg; I, 1.7 mg and Se, 300 μg.

表 3. 葉用枸杞一般成分及機能性成分分析 (乾基)

Table 3. Proximate and functional components analysis of *LC*M (dry matter)

Item	Top of section[a]	Lower section[b]
	Proximate analysis of *LC*M	
Moisture, %	5.10	4.49
Crude ash, %	6.34	3.09
Crude protein, %	17.96	9.56
Crude fat, %	2.24	1.20
Crude fiber, %	26.83	45.96
Acid detergent fiber, %	—	51.54
Neutral detergent fiber, %	—	65.49
Nitrogen-free extract, %	41.53	35.70
	Functional components analysis of *LC*M	
Total phenols, mg/g	33.33	9.94
Chlorogenic acid, mg/g	22.37	6.68
Rutin, mg/g	9.79	4.87
Selenium, ppm	0.84	0.38

[a] Means plant top buds with stems and leaves that are not lignified.
[b] Means plant lignified stem with few mature leaves.

II. 試驗設計

試驗一使用 4 週齡白羅曼母鵝 60 隻，逢機分配至對照組及 3 個處理組，對照組乾基精料 (89% 乾基) 任飼，處理組之精料給飼量以對照組前 3 至 7 日平均採食量為基準限飼，每組 3 重複，以欄為重複，每欄 5 隻。*LC*M 材料由苗改場及彰化場提供，*LC*M 使用植株頂芽、未木質化無刺之新鮮嫩莖及葉片，材料剪段約 1 － 3 公分後，分別依基準精料量 5、10 或 15% (鮮重) 餵飼鵝隻。試驗期為 5 － 12 週齡，每日記錄各欄飼料及 *LC*M 剩餘量，每 4 週收集體重資料，同時每欄逢機挑選 2 隻鵝採集腳脛靜脈血樣後進行血液生化值分析。

試驗二使用 2 週齡白羅曼公鵝 60 隻，逢機分配至對照組及 3 個處理組，於基礎精料中分別添加 0、1、3 或 5% 之乾燥 *LC*M 粉，以取代精料配方中等比例之苜蓿粉。每組 3 重複，以欄為重複，每欄 5 隻。試驗使用 *LC*M 下段木質化莖稈 (含少許葉片) 由苗改場提供，經低溫長時間烘乾後粉碎製成 *LC*M 粉。於 3 － 12 週齡進行試驗，鵝隻飼料及飲水任飼，每週收集飼糧採食量及於 4、8 及 12 週齡收集體重資料，同時每欄逢機挑選 2 隻鵝採集腳脛靜脈血樣後進行血液生化值分析。

III. 測定項目與方法

試驗期間收集各欄鵝群體重及飼糧採食量，供計算飼料換肉率 (Feed conversion ratio, FCR)。鵝隻血樣經 4℃、1,610 g 離心 15 分鐘後 (Hettich UNIVERSAL 320R)，再以 LANNER T-900 血液生化分析儀搭配同廠牌之試劑進行肌酸酐 (Creatinine, CREA)、麩胺草醋酸轉胺酶 (Glutamic oxaloacetic transaminase, GOT)、麩胺丙酮酸轉胺酶 (Glutamic - pyruvic transaminase, GPT)、膽固醇 (Cholesterol, CHOL)、三酸甘油酯 (Triglyceride, TG)、抗氧化物 (Antioxidants, AntiOxs)、過氧化氫酶 (Catalase, CAT) 及超氧化物歧化酶 (Superoxide dismutase, SOD) 含量分析。

IV. 統計分析

試驗所得數據利用 SAS 套裝軟體一般線性模式 (General linear model) 程序進行變方分析 (SAS, 2014)，如有顯著差異效應，再以 Tukey's studentized range test 比較各組間差異顯著性，顯著差異水準為 $P < 0.05$。

結果與討論

新鮮葉用枸杞對 5 － 12 週齡白羅曼母鵝生長性能之影響列示於表 5。結果顯示，3 個處理組新鮮葉用枸杞採食比例分別為餵飼狀態基準精料給飼量之 5.2、9.9 及 14.9% (鮮基重)。對照組鵝隻在 5 － 8 週齡之隻日採食量 (精料加 *LC*M，全乾基計算) 顯著高於其他處理組 ($P < 0.05$)，顯示生長期提供新鮮 *LC*M 會降低鵝隻採食量，但不影響

飼料轉換率，另 5 － 12 週齡各組鵝隻之隻日採食量無顯著差異 (表 4)。對照組鵝隻 8 週齡體重顯著高於其他新鮮葉用枸杞組，且 9.9 及 14.9% *LC*M 處理組鵝隻 5 至 8 週齡增重顯著低於對照組 ($P < 0.05$)；另 14.9% *LC*M 處理組之飼料轉換率顯著較對照組差 ($P < 0.05$)。許 (2001) 指出，鵝隻採食青飼料有其上限，過多的青飼料會使食糜停留在消化道的時間變短，營養分消化率下降，飼料效率變差，惟以 100% 全乾基採食量計算其飼料轉換率，則各組間無顯著差異。另總增重以 9.9% *LC*M 處理組較對照組增加 3.1%，惟達 12 週齡時各組總採食量、增重、飼料轉換率及 100% 全乾基飼料轉換率皆無顯著差異 (表 5)。在血液生化值方面，8 及 12 週齡 9.9% *LC*M 處理組之 CHOL 濃度分別較對照組低 6.6 和 21.8%。整體而言，給予新鮮 *LC*M 對 12 週齡鵝隻血清中 CREA、GOT、GPT、CHOL、TG、AntiOxs、CAT 及 SOD 並無顯著差異 (表 7)。綜上所述，飼糧中額外給予新鮮葉用枸杞頂芽與葉片至 14.9%，對鵝隻生長性能及血液生化值無不良影響。Yi (2000) 研究顯示，添加 *LC*M 粉於大鼠飼糧中，其血清中 TG 及 CHOL 濃度明顯下降，顯示 *LC*M 具有降血脂作用，本試驗結果發現給予新鮮 *LC*M 對鵝隻血清中之 TG 及 CHOL 濃度並無顯著影響，推測與試驗物種不同有關。

表 4.　白羅曼母鵝於 5 － 12 週齡之新鮮葉用枸杞與飼料採食量

Table 4.　Consumptions of fresh *LC*M and feed in female White Romam geese from 5 ~ 12 weeks of age

Weeks of age	Fresh *LC*M supplement (%)			
	0	5.2	9.9	14.9
	Feed consumption, g/bird/day			
5 － 8	321.66 ± 6.10[*a]	295.18 ± 4.93[b]	294.40 ± 9.53[b]	294.75 ± 3.97[b]
9 － 12	283.65 ± 13.53	274.87 ± 26.39	283.20 ± 22.06	280.78 ± 15.31
5 － 12	302.66 ± 6.41	285.03 ± 15.64	288.80 ± 15.63	287.77 ± 9.55
	*LC*M consumption, g/bird/day			
5 － 8	－	14.81 ± 0.32[c]	29.46 ± 0.49[b]	44.05 ± 0.81[a]
9 － 12	－	14.96 ± 0.29[c]	27.93 ± 2.43[b]	41.72 ± 0.34[a]
5 － 12	－	14.88 ± 0.19[c]	28.70 ± 1.34[b]	42.88 ± 0.32[a]
	Feed consumption, g dry matter/bird/day			
5 － 8	285.31 ± 5.41[a]	261.82 ± 4.37[b]	261.13 ± 8.45[b]	261.45 ± 3.53[b]
9 － 12	251.61 ± 12.00	243.81 ± 23.41	251.20 ± 19.57	249.05 ± 13.58
5 － 12	268.46 ± 5.69	252.82 ± 13.87	256.16 ± 13.86	255.25 ± 8.47
	*LC*M consumption, g dry matter/bird/day			
5 － 8	－	3.70 ± 0.08[c]	7.37 ± 0.12[b]	11.01 ± 0.21[a]
9 － 12	－	3.74 ± 0.07[c]	6.98 ± 0.61[b]	10.43 ± 0.89[a]
5 － 12	－	3.72 ± 0.05[c]	7.18 ± 0.34[b]	10.72 ± 0.08[a]
	Total feed consumption, g dry matter/bird/day (feed + *LC*M consumption)			
5 － 8	285.31 ± 5.41[a]	265.53 ± 4.34[b]	268.49 ± 8.55[b]	272.46 ± 3.97[b]
9 － 12	251.61 ± 12.00	247.55 ± 23.48	258.18 ± 20.18	259.48 ± 13.63
5 － 12	268.46 ± 5.69	256.54 ± 13.89	263.34 ± 14.20	265.97 ± 8.40

*Means ± standard deviation.

[a, b, c] Means in the same row without a common superscript differ significantly ($P < 0.05$).

表 5. 新鮮葉用枸杞對 4 － 12 週齡白羅曼母鵝生長性能之影響

Table 5. Effects of fresh *LC*M on growth performances in female White Romam geese from 4 ~ 12 weeks of age

Weeks of age	Fresh *LC*M supplement (%)			
	0	5.2	9.9	14.9
	Body weight, kg/bird			
4	2.71 ± 0.03*	2.51 ± 0.09	2.66 ± 0.03	2.55 ± 0.16
8	4.96 ± 0.08[a]	4.53 ± 0.15[b]	4.36 ± 0.13[b]	4.52 ± 0.17[b]
12	5.41 ± 0.29	5.07 ± 0.35	5.44 ± 0.17	5.13 ± 0.25
	Body weight gain, kg/bird			
5 － 8	2.25 ± 0.11[a]	2.02 ± 0.06[ab]	1.97 ± 0.10[b]	1.97 ± 0.11[b]
9 － 12	0.45 ± 0.21	0.54 ± 0.20	0.81 ± 0.05	0.61 ± 0.16
5 － 12	2.60 ± 0.37	2.56 ± 0.88	2.78 ± 0.93	2.58 ± 0.52
	Total feed conversion ratio, kg feed/kg gain (feed + *LC*M consumption)			
5 － 8	3.30 ± 0.16[b]	3.53 ± 0.05[b]	3.66 ± 0.93[ab]	3.97 ± 0.52[a]
9 － 12	21.16 ± 10.22	16.97 ± 5.62	11.12 ± 0.35	15.87 ± 3.28
5 － 12	5.84 ± 0.56	6.09 ± 0.29	5.92 ± 0.10	6.66 ± 0.35
	Total feed conversion ratio, kg dry matter/kg gain (feed + *LC*M consumption)			
5 － 8	2.92 ± 0.14	3.03 ± 0.05	3.14 ± 0.11	3.19 ± 0.21
9 － 12	18.77 ± 9.07	14.48 ± 4.75	9.23 ± 0.29	12.76 ± 2.60
5 － 12	5.21 ± 0.51	5.23 ± 0.26	4.92 ± 0.08	5.37 ± 0.28

[1] Fresh *LC*M supplement is calculated as 5.2, 9.9 or 14.9% (fresh weight basis) of concentrate.

* Means ± standard deviation.

[a, b] Means in the same row without a common superscript differ significantly ($P < 0.05$).

表 6. 乾燥葉用枸杞粉對於 2 － 12 週齡白羅曼公鵝生長性能之影響

Table 6. Effects of dry *LC*M powder on growth performances in male White Romam geese from 2 ~ 12 weeks of age

Weeks of age	Dry *LC*M powder supplement (%)			
	0	1	3	5
	Body weight, g/bird			
2	0.74 ± 0.07*	0.73 ± 0.07	0.71 ± 0.07	0.71 ± 0.08
4	2.21 ± 0.07	2.20 ± 0.09	2.16 ± 0.05	2.20 ± 0.03
8	4.09 ± 0.12	4.14 ± 0.16	4.07 ± 0.10	4.04 ± 0.03
12	4.73 ± 0.10	4.77 ± 0.18	4.69 ± 0.07	4.73 ± 0.12
	Body weight gain, kg/bird			
3 － 4	1.51 ± 0.04	1.52 ± 0.05	1.45 ± 0.04	1.50 ± 0.01
5 － 8	1.89 ± 0.65	1.94 ± 0.17	1.90 ± 0.10	1.84 ± 0.01
9 － 12	0.63 ± 0.02	0.63 ± 0.04	0.62 ± 0.03	0.69 ± 0.15
5 － 12	4.03 ± 0.02	4.09 ± 0.24	3.97 ± 0.03	4.03 ± 0.14
	Feed intake, kg/bird			
3 － 4	2.85 ± 0.08	2.89 ± 0.18	2.80 ± 0.08	2.85 ± 0.07
5 － 8	6.69 ± 0.33	6.29 ± 0.39	6.24 ± 0.10	6.53 ± 0.14
9 － 12	7.08 ± 0.57	6.80 ± 1.08	6.89 ± 0.40	7.10 ± 0.49
5 － 12	16.62 ± 0.96	15.97 ± 1.62	15.92 ± 0.23	16.48 ± 0.39
	Feed conversion ratio, kg feed/kg gain			
3 － 4	1.89 ± 0.04	1.89 ± 0.06	1.93 ± 0.10	1.90 ± 0.03
5 － 8	3.55 ± 0.27	3.25 ± 0.17	3.28 ± 0.11	3.55 ± 0.09
9 － 12	11.16 ± 0.53	10.76 ± 1.27	11.11 ± 0.24	10.60 ± 2.01
5 － 12	4.13 ± 0.24	3.90 ± 0.19	4.01 ± 0.09	4.09 ± 0.10

* Means ± standard deviation.

There are no significant differences in the traits between treatments.

表 7.　新鮮葉用枸杞餵飼對 8 及 12 週齡白羅曼母鵝血液生化值之影響

Table 7.　Effects of feeding fresh *LC*M on blood biochemical parameters in female White Romam geese at 8 and 12 weeks of age, respectively

Parameter	Fresh *LC*M supplement (%)			
	0	5.2	9.9	14.9
	8 weeks of age			
TG[1], mg/dL	114.67 ± 39.11[*]	90.83 ± 13.33	82.17 ± 22.30	104.00 ± 26.46
CHOL[1], mg/dL	132.00 ± 29.93	128.67 ± 10.50	123.33 ± 38.61	140.17 ± 17.67
GOT[1], IU/L	13.50 ± 2.60	12.83 ± 1.53	11.50 ± 2.18	15.50 ± 0.87
GPT[1], IU/L	7.67 ± 1.89	8.00 ± 3.04	8.33 ± 1.89	9.33 ± 2.02
CREA[1], mg/dL	0.10 ± 0.06	0.11 ± 0.02	0.13 ± 0.07	0.14 ± 0.06
AntiOx[1], mM	0.47 ± 0.20	0.43 ± 0.08	0.40 ± 0.14	0.43 ± 0.04
CAT[1], nmol/min/mL	10.00 ± 1.62	7.74 ± 1.12	8.03 ± 2.74	6.13 ± 1.71
SOD[1], U/mL	28.70 ± 15.21	30.79 ± 8.71	23.23 ± 16.89	29.57 ± 8.96
	12 weeks of age			
TG, mg/dL	109.17 ± 27.62	111.83 ± 35.85	138.67 ± 17.25	105.33 ± 16.02
CHOL, mg/dL	202.67 ± 47.71	197.50 ± 19.70	158.50 ± 17.04	168.83 ± 22.21
GOT, IU/L	15.33 ± 2.08	14.17 ± 1.61	17.67 ± 3.55	14.33 ± 2.36
GPT, IU/L	11.33 ± 1.61	9.67 ± 1.04	9.67 ± 1.23	10.83 ± 0.29
CREA, mg/dL	0.24 ± 0.05	0.24 ± 0.12	0.20 ± 0.02	0.31 ± 0.05
AntiOx, mM	0.69 ± 0.19	0.70 ± 0.16	0.69 ± 0.14	0.71 ± 0.05
CAT, nmol/min/mL	8.81 ± 1.81	9.16 ± 0.98	8.08 ± 2.15	7.19 ± 1.07
SOD, U/mL	31.20 ± 4.57	30.36 ± 11.12	23.70 ± 5.70	22.36 ± 8.30

[*] Means ± standard deviation (n = 6).

[1] TG: triglyceride; CHOL: cholesterol; GOT: glutamic oxaloacetic transaminase; GPT: glutamic-pyruvic transaminase; CREA: creatinine; AntiOxs: antioxidants; CAT: catalase; SOD: superoxide dismutase. There are no significant differences in the parameters between treatments.

試驗二結果顯示，飼糧中添加乾燥 *LC*M 粉取代等比例之苜蓿粉，對鵝隻之總採食量、增重及飼料轉換率均無顯著影響 (表 6)，另分別計算 0、1、3 及 5% 乾燥 *LC*M 粉處理組之蛋白質效率比 (Protein efficiency ratio, PER)，分別為 1.42 ± 0.08、1.51 ± 0.07、1.51 ± 0.03 及 1.49 ± 0.04，結果顯示，在 3 及 5% 處理組蛋白質效率比較高，惟各組間未達顯著差異。在血液生化值方面，12 週齡鵝隻之 CHOL 濃度以添加 3% 組較對照組低 8.6%。整體而言，鵝隻血清中 CREA、GOT、GPT、CHOL、TG、AntiOxs、CAT 及 SOD 濃度於各組間均無顯著差異 (表 8)。本試驗使用之乾燥 *LC*M 粉之硒含量為 0.38 ppm (表 3)，施 (2009) 研究結果顯示，飼糧中添加 0.15 ppm 硒含量對白羅曼母鵝第 4 產期之最終體重、血液生化值及相關酵素活性均無顯著影響。王等 (2011) 研究結果顯示，飼糧中添加不同硒源對鵝隻生產和屠宰性能雖無顯著影響，但能改善鵝肉品質及其肌肉營養成分含量，且能增加免疫功能和抗氧化能力。本研究使用硒含量較高之葉用枸杞莖稈粉取代飼糧中之苜蓿粉，與前人之研究結果相似。另葉用枸杞萃取物對乙醇誘導急性胃病變動物模型之小鼠試驗結果顯示，葉用枸杞萃取物具有顯著降低小鼠血清中丙二醛脂質過氧化物 (Malondialdehyde, MDA) 及提升血清 SOD 活性之能力 (Olatunji *et al.*, 2015)。綜上可知，飼糧中添加乾燥葉用枸杞莖稈粉至 5%，對鵝隻生長性能、血液生化值無不良影響，惟後續可對鵝肉品質做進一步探討。

表 8. 乾燥葉用枸杞粉餵飼對 4、8 及 12 週齡白羅曼公鵝血液生化值之影響

Table 8. Effects of feeding dry *LC*M powder on blood biochemical parameters in male White Romam geese at 4, 8 and 12 weeks of age, respectively

Parameter	Dry *LC*M powder supplement (%)			
	0	1	3	5
	4 weeks of age			
TG[1], mg/dL	170.67 ± 44.33*	252.00 ± 180.15	157.00 ± 57.60	130.17 ± 38.89
CHOL[1], mg/dL	155.17 ± 14.58	151.17 ± 9.28	166.67 ± 16.50	163.17 ± 27.60
GOT[1], IU/L	18.50 ± 3.00	23.33 ± 1.89	23.17 ± 3.69	33.00 ± 14.24
GPT[1], IU/L	12.57 ± 2.50	12.00 ± 1.32	12.17 ± 0.29	14.50 ± 3.04
CREA[1], mg/dL	0.02 ± 0.02	0.03 ± 0.03	0.01 ± 0.00	0.01 ± 0.01
AntiOx[1], mM	1.01 ± 0.11	0.10 ± 0.31	0.61 ± 0.25	0.74 ± 0.39
CAT[1], nmol/min/mL	6.29 ± 0.53	6.83 ± 3.16	5.99 ± 1.11	6.08 ± 0.36
SOD[1], U/mL	11.55 ± 2.93	11.23 ± 0.89	11.05 ± 2.72	10.95 ± 0.71
	8 weeks of age			
TG, mg/dL	84.67 ± 12.00	107.50 ± 32.05	64.50 ± 7.05	91.00 ± 15.62
CHOL, mg/dL	108.67 ± 19.69	104.00 ± 18.99	101.17 ± 12.35	110.33 ± 11.25
GOT, IU/L	15.00 ± 2.65	15.17 ± 1.61	15.50 ± 1.80	14.00 ± 2.78
GPT, IU/L	8.33 ± 1.26	9.83 ± 0.76	6.83 ± 0.58	8.50 ± 1.32
CREA, mg/dL	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
AntiOx, mM	0.81 ± 0.08	0.74 ± 0.03	0.77 ± 0.07	0.68 ± 0.14
CAT, nmol/min/mL	5.25 ± 1.33	4.83 ± 1.22	5.15 ± 0.82	4.69 ± 0.49
SOD, U/mL	17.50 ± 4.99	21.77 ± 3.36	16.10 ± 3.28	18.00 ± 2.25
	12 weeks of age			
TG, mg/dL	79.50 ± 29.10	103.67 ± 18.91	78.83 ± 10.56	86.00 ± 8.32
CHOL, mg/dL	180.50 ± 19.69	172.33 ± 18.99	165.00 ± 12.35	179.50 ± 11.25
GOT, IU/L	14.00 ± 0.50	17.83 ± 4.48	15.83 ± 4.16	14.33 ± 1.53
GPT, IU/L	8.67 ± 0.29	9.83 ± 0.76	6.35 ± 2.57	7.50 ± 0.87
CREA, mg/dL	0.06 ± 0.04	0.09 ± 0.05	0.03 ± 0.03	0.07 ± 0.01
AntiOx, mM	0.81 ± 0.16	0.73 ± 0.22	0.44 ± 0.03	0.58 ± 0.31
CAT, nmol/min/mL	3.11 ± 0.34	3.02 ± 0.11	2.71 ± 0.17	2.59 ± 0.34
SOD, U/mL	34.13 ± 4.62	37.49 ± 6.33	33.41 ± 8.30	34.87 ± 9.83

* Means ± standard deviation (n = 6).

[1] TG: triglyceride; CHOL: cholesterol; GOT: glutamic oxaloacetic transaminase; GPT: glutamic-pyruvic transaminase; CREA: creatinine; AntiOxs: antioxidants; CAT: catalase; SOD: superoxide dismutase. There are no significant differences in the parameters between treatments.

試驗二使用之 *LC*M 下段木質化莖稈 (含少許葉片) 經攝氏 50℃烘乾 48 h 製成，其一般營養成分分析結果顯示，水分 4.49%、粗蛋白質 9.56%、粗纖維 45.96%、粗灰分 3.09%、粗脂肪 1.2% 及無氮抽出物 35.7%、酸洗纖維 51.54% 及中洗纖維 65.49%，並含有總酚 (Total phenols)、綠原酸 (Chlorogenic acid) 及芸香苷 (Rutin) 等多種機能性成分 (表 3)。劉等 (2010) 發現 *LC*M 之硒含量較常見蔬菜高，硒是動物體內必需營養素，缺乏會造成疾病和免疫系統損害 (Finley, 2005)。王 (2019) 研究發現蜱癭可增加枸杞葉片的機能性成分含量，且此類中草藥品質的好壞取決於有效成分或活性成分含量的多寡，其與產地、品種、栽培技術和採收的年限、季節、時間及方法等均有密切關係 (張，2006)，顯示 *LC*M 之機能性成分含量會受季節、產地及病蟲害等影響。

本研究初次嘗試以新興機能性蔬菜「葉用枸杞」與白羅曼肉鵝飼糧做結合，試驗結果顯示，飼糧中添加乾燥葉用枸杞粉至 5% 或基礎飼糧額外給予新鮮葉用枸杞頂芽與葉片至 14.9%，對 12 週齡白羅曼鵝之生長性能及血液生化值均無不良影響。惟新鮮葉用枸杞保存不易，且植株莖稈多刺，經試驗木質化部位嗜口性不佳，不宜直接供鵝隻鮮食，餵飼需耗費人力細切處理、費時費工，增加間接成本。相較之下，乾燥粉末化之 *LC*M 作為鵝隻飼料原料使用較為便利，由於其富含硒元素及植生素機能性成分，後續將探究其對鵝隻保健之功效。

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The Effects of diets supplemented with *Lycium chinense* Miller on growth performances and blood biochemical parameters in White Roman geese [1]

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Abstract

The study aimed to investigate the effects of fresh (top section) or dry (lignified stalk) *Lycium chinense* Miller (*LC*M) on growth performances and blood biochemical parameters of White Roman geese. At the first stage, a total of sixty females were randomly divided into the control group and 3 treatment groups, whereas the 3 replicates (5 geese per pen) were set up in the study at the 5th to 12th week of age. The control group was fed with *ad libitum*, and the concentrate of other treatment group limited to feeding based on the average feed intake of the control group in the first 3 to 7 days, and supplemented with 5, 10 and 15% of fresh *LC*M (top section), respectively. After the experiment was completed, the ratio of feed intake of the three fresh *LC*M treatments were calculated as 5.2, 9.9 or 14.9% (fresh weight basis). The results showed that significantly higher body weight (BW) was observed in the control group at the 8 week of age, whereas the higher body weight gain (BWG) at the 5th to 8th week of age was observed in control group, when compared with the treatments supplemented with 9.9 and 14.9% fresh *LC*M. Moreover, the levels of creatinine (CREA), glutamic-oxaloacetic transaminase (GOT), glutamic-pyruvic transaminase (GPT), triglyceride (TG), cholesterol (CHOL), antioxidants (AntiOxs), catalase (CAT) and superoxide dismutase (SOD) showed no significant difference between each group at the 8th and 12th week of age. At the second stage, a total of sixty males were randomly divided into control group and 3 treatment groups. The percentage of 0, 1, 3 or 5 of dry *LC*M lignified stalk powder were supplemented to daily diets, whereas the 3 replicates (5 geese per pen) were set up in the study from the 3rd to 12th week of age. The results showed no significant differences between each treatment for feed intake, BWG and FC. For the blood biochemical parameters, the levels of CREA, GOT, GPT, TG, CHOL, AntiOxs, CAT and SOD showed no significant differences between each group at the 12th week of age. In summary, there were no adverse effects on the growth performances and blood biochemical parameters when feed with concentrate supplement of 14.9% fresh *LC*M (fresh weight basis) and 5% *LC*M lignified stalk powder in geese. The *LC*M can be used as a source of crude fiber in meat-type geese.

Key words: *Lycium chinense* Miller, Growth performance, Blood biochemical parameter, White Roman geese.

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行政院農業委員會畜產試驗所「畜產研究」稿約

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