

# 日糧中補充益生菌對泌乳羊於臺灣熱季乾物質採食量、泌乳量及乳成分之影響<sup>(1)</sup>

鄭閔謙<sup>(2)</sup> 王紓愍<sup>(2)</sup> 潘昭治<sup>(2)(3)</sup>

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## 摘 要

氣候變遷會影響畜牧業永續發展，因為高溫會導致羊隻發生熱緊迫，進而降低乳羊生產效率，嚴重損害農民經濟收入。本研究目的旨在探討飼糧補充植物乳桿菌 (*Lactobacillus plantarum*) 與乾酪乳桿菌 (*Lactobacillus casei*) 對泌乳羊於臺灣熱季乾物質採食量、泌乳量及乳成分之影響。試驗為拉丁方格設計，將 9 頭努比亞山羊逢機分 3 個處理組，分別為盤固乾草組 (PGH)、盤固草添加 *Lactobacillus plantarum* 與 *Lactobacillus casei* 組 (PKT) 及百慕達乾草組 (BMH)。試驗週期為 21 天，包含 7 天試驗期，試驗重複 3 個週期。乳羊每日早晚餵飼與擠乳。試驗結果顯示，PKT 組之乾物質採食量顯著高於其他各組，然乳產量、乳成分 (乳脂肪、乳蛋白質、乳糖、無脂固形物、體細胞數、總固體及乳中尿素氮) 及血液成分於各組間並無顯著差異。雖然羊乳體細胞數於統計上並無顯著影響，但從數據發現，其可能有降低羊乳體細胞數之潛力。綜上所述，飼糧中添加益生菌可提高乳羊在夏季時之乾物質採食量，改善乳羊於夏季因熱緊迫造成乾物質採食量不足問題。

關鍵詞：乳羊、植物乳桿菌、乾酪乳桿菌。

## 緒 言

氣候變遷是影響畜牧永續發展主要威脅之一，特別在熱帶和亞熱帶國家 (Das *et al.*, 2016)。山羊不需額外增加代謝熱能產生之熱中性區 (thermoneutral zone) 約為 12 – 24°C。當環境溫度過高時，羊隻為維持體內熱平衡而啟動調節生理代謝機制，進入熱緊迫狀態 (Marai and Habeeb, 2010)。熱緊迫會影響山羊血液學、生理學和生化參數 (Ocak *et al.*, 2010; Phulia *et al.*, 2010; Alam *et al.*, 2011; Gupta and Monda, 2021)。同時也會對採食、生長、生產、繁殖產生負面影響，進而降低免疫力，使羊隻更容易生病，甚至死亡 (Rashamol *et al.*, 2018)。

臺灣地處亞熱帶與熱帶區域，近年熱季高溫屢創新高，山羊於夏季時常面臨熱緊迫風險。因此，除改善羊舍通風與增加降溫設備外，許多研究也指出可透過飼料添加物提高羊隻免疫與抗氧化能力來預防熱緊迫 (Xue *et al.*, 2022; Qiu *et al.*, 2023)。乳酸菌為革蘭氏陽性菌，通常被認為是益生菌代表菌種之一 (Fijan, 2014)，已被廣泛應用於單胃與反芻動物之飼料添加物 (Maragkoudakis *et al.*, 2010)。乳酸菌可改善胃腸環境，提高飼糧採食量與消化效率，且可在瘤胃中產生有機酸及抗菌肽進行抗菌作用 (Kim *et al.*, 2020)。另一方面，有許多研究指出乳酸菌細胞外分泌物具強烈抗氧化活性，可清除自由基，有抗發炎與抗氧化壓力能力 (Wu *et al.*, 2014; Chen *et al.*, 2020)。*Lactobacillus plantarum* 與 *Lactobacillus casei* 除具上述乳酸菌功效之外，亦可在廣泛環境溫度與 pH 值範圍內生存，常被作為益生菌使用於飼料添加物。

盤固草為國內調製乾草用的主要牧草品種 (李等, 1999 年)，依據 112 年農業年報數據顯示，全國盤固草種植面積達 2,667 公頃，產量達 200,166 公噸 (農業年報, 2024 年)。百慕達草則為國內近年進口量最大的禾本科牧草 (Wang *et al.*, 2024)。盤固草與百慕達草為國內羊場重要之芻料來源，但兩者每公斤價差可高達 1 倍之多。如能藉由添加益生菌提高盤固草利用價值，將能替羊農節省大量飼養成本。因此本試驗目的為於熱季時在以盤固草為主之泌

(1) 農業部畜產試驗所研究報告第 2845 號。

(2) 農業部畜產試驗所南區分所。

(3) 通訊作者，E-mail: ppncc@mail.tlri.gov.tw。

乳羊飼糧中添加 *Lactobacillus plantarum* 與 *Lactobacillus casei*，探討對其採食量與泌乳性能之影響。

## 材料與方法

### I. 乳酸菌來源與餵飼濃度

使用農業部畜產試驗所南區分所研發菌種，該菌種已技術移轉予生合生物科技股份有限公司所生產之商品 芯發旺®。該商品內容為 *Lactobacillus plantarum* 與 *Lactobacillus casei*，配製後飼料之菌數為  $1 \times 10^8$  CFU/g。每頭羊每天餵飼 0.8 公斤飼料。益生菌餵飼濃度參考前人研究設計，為每頭羊每天攝食約  $8 \times 10^{10}$  CFU (Stella *et al.*, 2007; Salvedia *et al.*, 2015)。

### II. 動物及飼養

本試驗執行時間為 2017 年 8 至 11 月。地點位於農業部畜產試驗所南區分所恆春場區試驗羊舍，該處位於臺灣南部，屬於熱帶型氣候區域 (北緯：21°，東經：120°)。試驗期間最高溫平均為 33.8°C，累積降水量為 1132.0 mm (氣象局，2025)，其特徵為高溫與高濕。試驗計畫經農業部畜產試驗所南區分所實驗動物小組審查通過 (LRI IACUC：106001)。

試驗泌乳羊為 9 頭已分娩 2 至 3 胎之努比亞山羊，平均分娩後  $60 \pm 10$  天，日泌乳量平均為  $1.5 \pm 0.2$  kg，平均體重為  $55 \pm 5.0$  kg。本試驗為拉丁方格輪替設計，將動物分成 3 個處理組，每個處理組 3 頭羊，試驗週期 21 天，包含 7 天試驗期，試驗重複 3 個週期。羊隻日糧給予乾草及精料分飼，處理組分別為盤固乾草日糧組 (PGH)、盤固乾草日糧添加益生菌組 (PKT)、百慕達乾草日糧組 (BMH)。山羊於每日上午 8:00 及下午 4:00 進行餵飼，飼料以限飼方式餵飼。確保飼料與益生菌會被完全採食。牧草則給予比每日採食量高約 10% 之餵飼量。早上餵飼前，先將前日剩餘草料清除，並秤重記錄，再餵飼經秤重記錄的乾草和飼料。草料與飼料依據 AOAC (2005) 方法測定水分含量，據以分析乾物質採食量。乳羊營養需求依據 NRC (2007) 標準，試驗配方如表 1 所示。試驗羊隻每日於早上與下午分別擠乳一次。

表 1. 試驗泌乳羊之日糧組成

Table 1. Composition of diets for dairy goats

Ingredients (of DM basis %)	Treatments		
	PGH	PKT	BMH
Composition			
Forage <sup>1</sup>			
Pangola hay	50	50	—
Bermuda hay	—	—	50
Concentrate			
Probiotics <sup>3</sup> (CFU/g)	—	$10^8$	—
Corn	36.6	36.6	36.6
Soybean meal	10.25	10.25	10.25
Calcium carbonate	0.95	0.95	0.95
Soybean oil	1.5	1.5	1.5
Salt	0.25	0.25	0.25
Vitamin premix <sup>4</sup>	0.25	0.25	0.25
Mineral premix <sup>5</sup>	0.20	0.20	0.20

PGH: pangola hay; PKT: pangola hay + probiotic; BMH: Bermuda hay.

<sup>1</sup> The forage is provided for *ad libitum*.

<sup>2</sup> Concentrates are offered on a restricted basis. Each goat is fed 0.8 kg of feed daily.

<sup>3</sup> Probiotic: *Lactobacillus plantarum* + *Lactobacillus casei*.

<sup>4</sup> Vitamin premix contained per kg: 7,000,000 IU vitamin A, 200,000 vitamin D, 55,000 vitamin E.

<sup>5</sup> Mineral premix contained per kg: 12.0 g Cu, 5 g Mn, 0.12 g Co, 16 g Zn, 1,200 mg I, 300 mg Se.

### III. 羊乳產量與成分分析

試驗期第 14 天與第 21 天收集並記錄每頭試驗羊隻之羊乳。再取其中 50 mL 樣品，儲存 4°C 寄送至社團法人中華民國乳業協會檢驗組檢測。分析項目為乳脂率、蛋白質率、乳糖率、無脂固形物、總固形物、體細胞數、尿素氮。

### IV. 血液生化分析

羊隻血液樣品在試驗期第 21 天時以頸靜脈採血方式收集至不含抗凝血劑之離心管中，在 2,500 × g 離心 20 分鐘收集血清，將其儲存於 -20°C 進行後續分析。血清中葡萄糖 (glucose)、尿素氮 (urea nitrogen, BUN)、尿酸 (uric acid, UA)、天門冬胺酸胺基轉移酶 (aspartate aminotransferase, AST) 及丙胺酸轉胺酶 (alanine aminotransferase, ALT)、總蛋白 (total protein)、白蛋白 (albumin)、球蛋白 (globulin)、膽固醇 (cholesterol)、三酸甘油酯 (triglyceride) 由雲林健康醫事檢驗所使用 Hitachi 7150 血液分析儀測量 (Hitachi, Tokyo, Japan)。

### V. 統計分析

試驗所得數據利用 SAS 套裝軟體進行統計分析 (SAS, 2018)，使用一般線性模式程序 (General linear model procedure, GLM) 進行變方分析，再以最小平方平均值法 (Least square means, LSMEANS) 計算並比較其差異顯著性。

## 結果與討論

飼糧添加 *Lactobacillus plantarum* 與 *Lactobacillus casei* 可顯著增加泌乳羊之乾物質採食量 (圖 1)。Paengkoum and Yong (2009) 在泰國研究指出，飼糧添加乳酸菌餵飼本地山羊與努比亞雜交山羊經 8 週後，可顯著提高其每日乾物質採食量。Khattab *et al.* (2020) 研究證明在埃及將母羊 (Barki sheep) 於分娩前 1 個月至分娩後 3 個月仔羊離乳前之期間給予益生菌補充，可顯著提高其乾物質採食量。乾物質攝取量取決於飼糧適口性、消化率與在胃腸道通過速率 (passage rate) (Melakua *et al.*, 2005)。乳酸菌可能是透過增加瘤胃發酵功能與纖維消化率而導致更高飼糧乾物質採食量 (Direkvandi *et al.*, 2021; Nasr and Abd-Alhalim, 2024)。

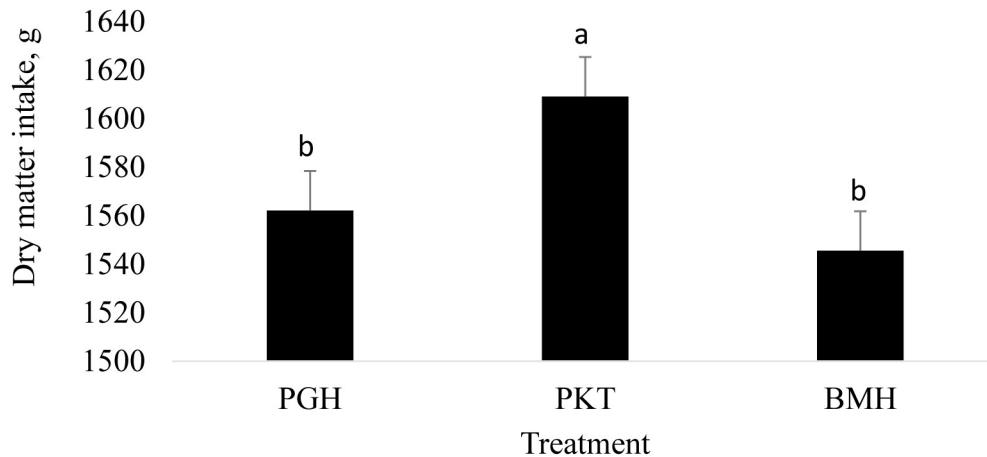


圖 1. 飼糧添加益生菌 (*Lactobacillus plantarum* 與 *Lactobacillus casei*) 對泌乳羊乾物質採食量之影響。

Fig. 1. Effect of dietary supplementation with probiotics (*Lactobacillus plantarum* and *Lactobacillus casei*) on dry matter intake in lactating goat.

PGH: pangola hay; PKT: pangola hay + probiotic; BMH: Bermuda hay.

餵飼不同飼糧對泌乳羊隻乳產量與乳成分之影響如表 2 所示。飼糧添加 *Lactobacillus plantarum* 與 *Lactobacillus casei* 對試驗羊隻之泌乳量無顯著影響。此結果與許多前人研究一致 (Griger-reverdin *et al.*, 1996; Salvedia *et al.*, 2017; Khattab *et al.*, 2020)。然而也有許多前人研究於飼糧中添加益生菌可提升乳羊之泌乳量 (Stella *et al.*, 2007; Salvedia *et al.*, 2015; Ma *et al.*, 2019)。益生菌影響乳羊泌乳量可能取決於多種因素，例如動物本身狀況 (遺傳、身體狀況和年齡)、環境 (溫度、濕度或病原體)、日糧種類 (纖維、糖和蛋白質)、餵飼時間及動物對益生菌之反應 (Salvedia *et al.*, 2015)。目前益生菌影響乳羊泌乳量之詳細機制尚不清楚 (Kritis *et al.*, 2006)。上述研究顯示益生菌對泌乳山羊之

乳產量有顯著提升，其所添加菌種皆為酵母菌，本次研究所使用之乳酸菌屬可能對乳山羊之乳產量較無顯著影響。

飼糧添加 *Lactobacillus plantarum* 與 *Lactobacillus casei* 對試驗羊隻之乳脂肪、乳蛋白質、乳糖、無脂固形物、總固體及乳中尿素氮並無顯著影響。此結果與前人報告相同 (Fayaz *et al.*, 2019; Khattab *et al.*, 2020)，然而也有許多研究發現於乳羊日糧添加益生菌可改變其乳成分 (Maragkoudakis *et al.*, 2010; Salvedia *et al.*, 2015; Kholif *et al.*, 2017)。Salvedia *et al.* (2015) 指出日糧補充益生菌可提高乳脂肪、無脂固形物、乳糖生產量。Ma *et al.* (2019) 研究顯示增加瘤胃纖維消化率會導致瘤胃乙酸含量上升，進而提高乳汁脂肪比率。瘤胃中營養消化率增加同樣能增進乳汁之乳糖比率。Stella *et al.* (2007) 指出品種與飼糧配方對乳成分影響可能大過於益生菌添加。

表 2. 飼糧添加益生菌 (*Lactobacillus plantarum* 與 *Lactobacillus casei*) 對泌乳羊乳產量與乳成分之影響

Table 2. Effect of dietary supplementation with probiotics (*Lactobacillus plantarum* and *Lactobacillus casei*) on milk yield and composition in lactating goat

	PGH	PKT	BMH	SEM
Milk yield, kg	1.095	1.0775	1.16	0.182
Fat, %	5.86	5.46	4.98	0.62
Protein, %	4.08	4.32	4.19	0.24
Lactose, %	4.20	3.97	4.02	0.20
Solids not fat, %	8.99	8.99	8.90	0.21
Total solids, %	14.85	14.77	14.23	0.75
SCC, $1 \times 10^4$ /mL	227	138	272	97
MUN, mg/dL	23.68	24.02	24.92	1.49

PGH: pangola hay; PKT: pangola hay + probiotic; BMH: Bermuda hay.

SCC: Somatic cell count; MUN: milk urea N.

雖然統計上飼糧添加 *Lactobacillus plantarum* 與 *Lactobacillus casei* 於泌乳山羊乳汁體細胞數無顯著差異，但從試驗數據發現可能有降低乳汁體細胞數之潛力。Salvedia and Supangco (2017) 餵飼罹患臨床性乳房炎努比亞與撒能雜交乳山羊連續 8 週之乳酸菌，試驗結果發現可顯著降低羊乳體細胞數。Jarczak *et al.* (2014) 在波蘭研究指出，乳羊從懷孕前 1 週至泌乳期第 240 天期間餵飼益生菌，可顯著降低乳汁體細胞數。益生菌可能對動物抑菌影響有幾種機制，病原菌需透過其表面菌毛附著在腸壁上才能發揮有害作用，菌毛為凝集素蛋白質組成，用以識別並選擇性地與腸壁上特定寡糖受體位點結合。日糧中添加益生菌，可增加生物體內非致病細菌數量增加，益生菌可以產生「細菌素」來中和致病菌釋放的毒素及產生乳酸、過氧化氫等物質，以抑制病原性細菌生長 (Ryan *et al.*, 1999; Vandana *et al.*, 2013)。

飼糧添加 *Lactobacillus plantarum* 與 *Lactobacillus casei* 對試驗羊隻血液之葡萄糖、總蛋白質、尿素氮、天冬氨酸氨基轉移酶、丙氨酸轉氨酶及三酸甘油酯並無顯著影響 (表 3)，與前人研究結果一致，皆在乳羊血液正常範圍值內 (Stella *et al.*, 2007)。此說明飼糧添加 *Lactobacillus plantarum* 與 *Lactobacillus casei* 並不會影響天冬氨酸氨基轉移酶與丙氨酸轉氨酶等肝臟功能指標。Paengkoum and Yong (2009) 每天餵飼安格魯努比亞山羊 (Anglo Nubian) 相當於  $5 \times 10^{11}$  至  $2 \times 10^{12}$  之 *S. cerevisie* 與 *Lactobacillus acidophilus* 混合會顯著增加血液尿素氮含量，Stella *et al.* (2007) 指出品種與飼糧配方對乳成分影響可能大過於益生菌添加，可能對血液影響效果雷同。

## 結 論

溫室效應導致氣候變遷，環境溫度異常升高似乎已是未來常見情況。飼糧中添加 *Lactobacillus plantarum* 與 *Lactobacillus casei* 可顯著提高泌乳羊於熱季時之乾物質採食量與降低乳汁體細胞數之潛力，對改善夏季熱緊迫有正面效果。

表 3. 飼糧添加益生菌 (*Lactobacillus plantarum* 與 *Lactobacillus casei*) 對泌乳羊血清成分之影響Table 3. Effect of dietary supplementation with probiotics (*Lactobacillus plantarum* and *Lactobacillus casei*) on serum parameters in lactating goat

	PGH	PKT	BMH	SEM
GLU, mg/dl	48.2	47.2	45.3	4.70
BUN, mg/dl	13.2	13.2	14.4	1.86
UA, mg/dl	0.09	0.08	0.08	0.03
AST, U/L	73.4	74.9	82.7	9.35
ALT, U/L	16.1	14.6	17.1	1.98
TP, g/dl	6.26	6.08	5.86	0.55
ALB, g/dl	3.01	2.94	2.97	0.29
GLO, g/dl	3.24	3.13	2.89	0.30
CHOL, mg/dl	73.6	78.4	72.9	9.09
TG, mg/dl	13.8	12.0	11.3	2.32

GLU: glucose. BUN: urea nitrogen. UA: uric acid. AST: aspartate aminotransferase. ALT: alanine aminotransferase. TP: total protein. ALB: albumin. GLO: globulin. CHOL: cholesterol. TG: triacylglycerol.

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# Effect of dietary supplementation with probiotics on dry matter intake, milk yield and composition of dairy goats under the hot season in Taiwan <sup>(1)</sup>

Min-Chein Cheng <sup>(2)</sup> Su-Min Wang <sup>(2)</sup> and Chao-Chih Pan <sup>(2) (3)</sup>

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## Abstract

Climate change has significant impacts on the sustainable development of animal husbandry. Elevated temperatures can induce heat stress in goats, thereby reducing the production efficiency of dairy goats and adversely affecting farmers' economic income. The objective of this project was to investigate the effects of dietary supplementation with *Lactobacillus plantarum* and *Lactobacillus casei* on dry matter intake, milk yield, and composition in dairy goats during the hot season in Taiwan. The experiment was designed as a Latin square and involved nine Nubian dairy goats that were randomly assigned to three treatment groups, namely hay (PGH), hay supplemented with *Lactobacillus plantarum* and *Lactobacillus casei* (PKT), and Bermuda grass (BMH). The trial lasted for 21 days, including a 7-day testing period, and was repeated three times. The dairy goats were fed and milked twice daily. The results indicated that the dry matter intake of the PKT treatment group was significantly higher than that of the other groups. However, no significant effects were observed on milk yield, milk components (milk fat, milk protein, lactose, non-fat solids, total solids, and urea nitrogen in milk), and blood components. The somatic cell count of goat milk did not show significant effect statistically. However, the data suggested that probiotics may have the potential to reduce the somatic cell count. In summary, incorporating probiotics into the feed can enhance the dry matter intake of dairy goats during the summer, which effectively improves the inadequacy of dry matter intake for dairy goats due to heat stress.

Key words: Dairy goat, *Lactobacillus plantarum*, *Lactobacillus casei*.

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(2) Southern Region Branch, TLRI, Pingtung 94644, Taiwan, R. O. C.

(3) Corresponding author, E-mail: ppncc@mail.tlri.gov.tw.