

乳脂肪酸、酪蛋白與酮體檢測
**Fatty Acid, Casein & Ketosis
Screening**

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大綱 Outline

- 臺灣DHI乳質檢驗
Raw milk quality in DHI (Dairy Herd Improvement) analysis, Taiwan
- 脂肪酸之應用
Application of fatty acids profile
- 游離脂肪酸之應用
Application of free fatty acids profile
- 酪蛋白之應用
Application of casein
- 酮症之篩選
Ketosis screening



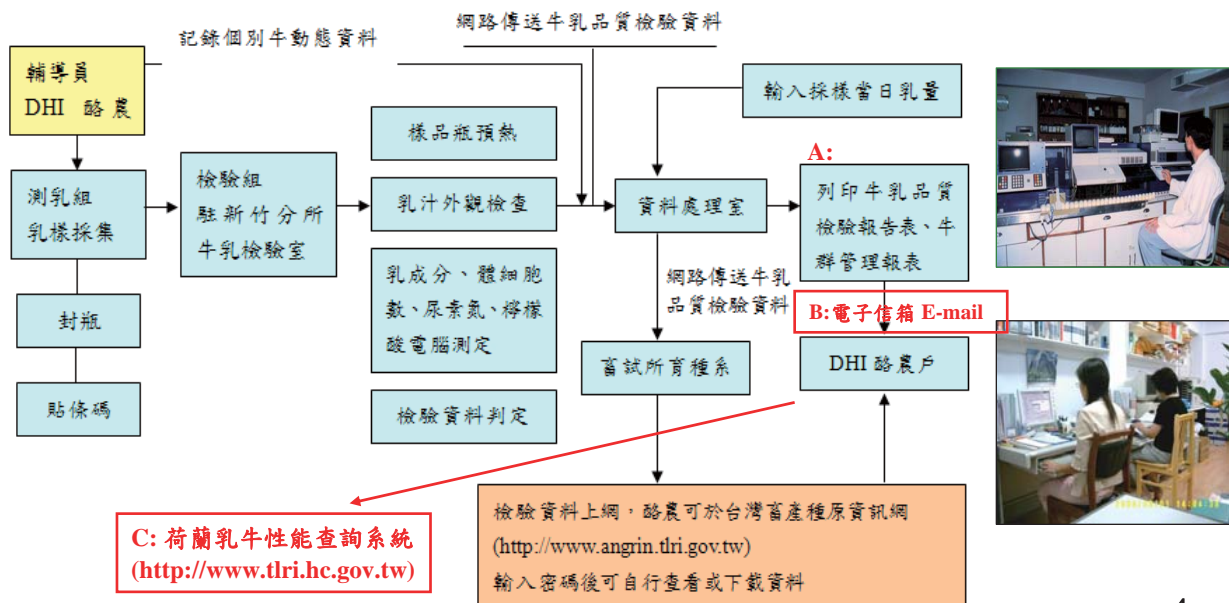
大綱 Outline

- 臺灣DHI乳質檢驗
Raw milk quality in DHI (Dairy Herd Improvement) analysis, Taiwan



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乳樣檢驗流程 Test milk samples



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臺灣DHI乳成分檢驗

Raw milk composition in DHI analysis, Taiwan

- Before 1978
milk fat 脂肪
- 1978 – 2002
milk fat, protein, lactose, solis-not-fat, total solids
脂肪、蛋白質、乳糖、無脂固形物、總固形物
- 2003 – 2013
milk fat, protein, lactose, solis-not-fat, total solids, **urea nitrogen, citric acid**
脂肪、蛋白質、乳糖、無脂固形物、總固形物、**尿素氮、檸檬酸**
- 2014
milk fat, protein, lactose, solis-not-fat, total solids, urea nitrogen, citric acid, **fatty acids, free fatty acids, casein, ketone bodies**
脂肪、蛋白質、乳糖、無脂固形物、總固形物、尿素氮、檸檬酸、**脂肪酸、游離脂肪酸、酪蛋白、酮體**

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DHI 頭數及戶數 DHI Farms

測乳年	戶數	頭數	乳樣數
2011	197	26,486	188,133
2012	186	26,227	181,334
2013	170	24,870	170,680



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乳成分分析儀檢測原理

Principal of milk analyzer

- 原有機型：紅外線（IR）光譜技術
Old type: Infrared（IR）technology
- 新機型：傅立葉轉換紅外線光譜（FTIR）技術
New type: Fourier Transform Infrared Spectroscopy（FTIR）technology



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大綱 Outline

- 脂肪酸之應用
Application of fatty acids profile



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乳脂肪酸檢測項目 Fatty acids profile

總飽和脂肪酸 (Total Saturated Fatty Acids)

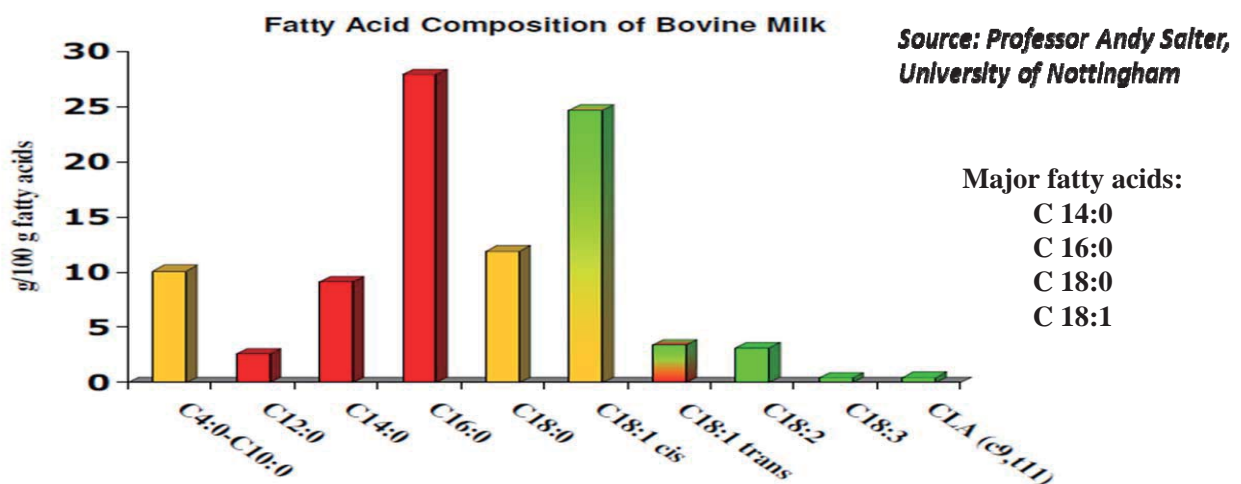
總不飽和脂肪酸 (Total Unsaturated Fatty Acids)

單元不飽和脂肪酸 (Mono Unsaturated Fatty Acids)

多元不飽和脂肪酸 (Poly Unsaturated Fatty Acids)



牛乳脂肪酸組成 Fatty acid composition of bovine milk



Major fatty acids:

- C 14:0
- C 16:0
- C 18:0
- C 18:1

短鏈 Short Chain Fatty Acids: C4 + C6 + C8 + C10

● 中鏈 Medium Chain Fatty Acids: C12 + C14 + C16

● 長鏈 Long Chain Fatty Acids: C18

■ 飽和程度 Degree of unsaturation

● 飽和脂肪酸 Saturated Fatty Acids

● 單元不飽和脂肪酸 Mono Unsaturated Fatty Acids

● 多元不飽和脂肪酸 Poly Unsaturated Fatty Acids

為何檢測乳脂肪酸

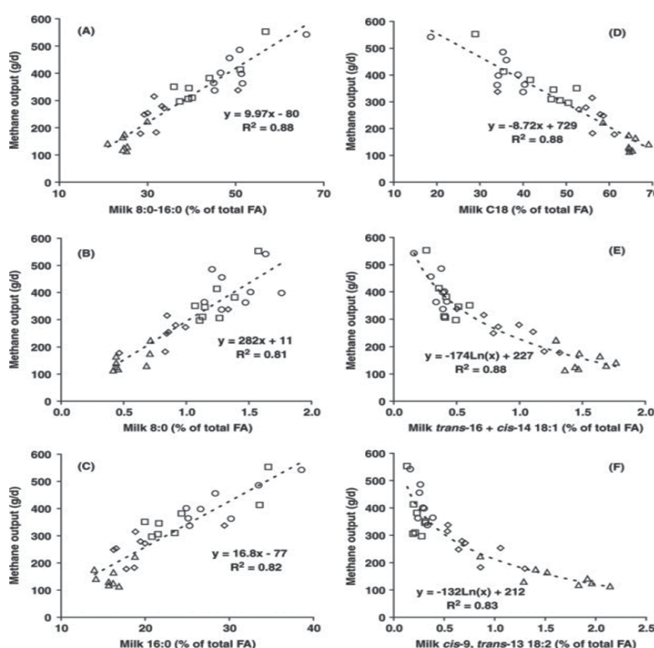
Why test fatty acids profile in milk

- 提升牛乳的營養形象，增加營養價值
- 消費者希望從飲食中攝取較佳的脂肪
 - 不飽和脂肪酸優於飽和脂肪酸，可減少不良膽固醇產生
 - 飽和脂肪酸可能導致心血管疾病發生
- 減少甲烷 (Methane) 排放，降低對環境之衝擊
- Fatty acids profile for improved healthy dairy products
- Consumers want to get the right fat from their diet
 - The fat should be unsaturated rather than saturated
 - High cholesterol levels causes heart diseases
- Cut in emission of methane to the atmosphere



乳脂肪酸的組成對甲烷排放量之影響

Milk fatty acid (FA) profiles - influence on methane output



- 初步結論：
- Preliminary conclusions:**
- 飽和脂肪酸含量愈高，甲烷排放量愈高
The more saturated FA, - the higher emission
 - C18脂肪酸含量愈高，甲烷排放量較低
The more C18 the lower emission
 - 不飽和脂肪酸含量愈高，甲烷排放量愈低
The more unsaturated fat the lower the emission

Source: [Journal of Dairy Science 2009; 92:5199-5211](#)

如何改善乳脂肪酸的組成 How to improve milk fatty acids profile

- **短期**- 改變飼養管理方式，生產不飽和脂肪酸含量較高之牛乳
Short term by changes in feeding to produce high level of unsaturated fatty acids in milk
- **長期**- 藉育種選拔，篩選可生產含量較高不飽和脂肪酸之牛隻
Long term by breeding in order to favor a specific fatty acid profile in milk



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乳脂肪酸組成的改善-以荷蘭試驗為例 To improve milk fatty acids profile -case study in the Netherlands

酪農戶為提升牛乳中不飽和脂肪酸的含量，使用**亞麻籽 (linseed)** 餵食泌乳牛隻，有400 個酪農戶參加，合計20 萬噸生乳

A Dutch dairy decided to feed the cows with more linseed in order to achieve milk with more unsaturated fatty acids. Now: 400 dairy farmers supplying 200 million liters of milk

成效Results :

- 不飽和脂肪酸增加 20%
20% more unsaturated fatty acids
- 飽和脂肪酸減少 10%
10% less saturated fatty acids
- Omega 3的含量增加 2 倍
twice the amount of Omega 3



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乳脂肪酸組成的改善-以臺灣試驗為例

To improve milk fatty acids profile -case study in Taiwan

- 飼糧添加富含亞麻油酸之大豆油可以顯著提高乳脂中共軛亞麻油酸 (CLA) 含量，且以添加 4% 大豆油處理組為最高 (陳等, 2009)。
- 國外許多研究報告證實 CLA 具有抗癌、抗動脈硬化與抗肥胖的作用，同時也具有刺激免疫功能的能力。反芻動物之乳、肉產品是人類食物中 CLA 之主要來源。報告指出，牛乳中的 CLA 含量佔總脂肪量 0.34-1.07%，並且利用動物模式証實平均成熟動物只要消耗 1/3-1/2 的 CLA 含量可顯著降低癌症發生率。
- Add 4% **soy beans oil** (**rich in linoleic acid**) in the diet for dairy cow
- conjugated linoleic acid (**CLA**) increased significantly (Chen *et al.*, 2009)



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大綱 Outline

- 游離脂肪酸之應用
Application of free fatty acids profile



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影響游離脂肪酸含量之因素 Impact factors of free fatty acids (FFA)

一、主要因素：牛乳中酵素之作用造成脂肪分解（Lipolysis），產生游離脂肪酸
FFA is the result of “Lipolysis”, which is an enzymatic process in the milk

二、其他因素：

生理：泌乳期；遺傳；季節

營養：日糧組成；微生物污染（酵素之作用）；乳房炎（酵素之作用）；擠乳過程及機械之影響：擠乳衛生、擠乳機之設計、冷卻、攪拌等；乳品廠生乳之運送及加工過程處理等

*FFA are influenced by: hygiene (microorganism), disease (mastitis), stage of lactation, heredity, seasonality, nutrition (composition of fodder), milk handling on the farm and in the factory etc.

*可由飼養管理來改善
Improved by feeding



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高量游離脂肪酸會影響產品風味及使用期限 FFA in dairy products and suppliers milk

- 高脂肪含量之乳製品（如：butter, cream等）發生酸敗現象（rancidity），致使產品帶有腐臭或肥皂水味

- Problems caused by higher FFA levels:

Rancidity in high-fat dairy products i.e. butter, cream

- 縮短乳製品使用期限（shelf life）

Milk with high levels of FFA decreased **shelf life** of milk products



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檢測FFA的理由 Why we test FFA in suppliers milk

- 一旦生乳含高濃度FFA，則無法經由加工來改善，FFA之含量為不可逆，且生乳及乳製品中之脂肪分解作用仍持續進行

Raw milk with high FFA levels cannot be “repaired”, the damage is done, and the enzymatic process continues

- 可輔導酪農改善

Farmers, who deliver milk with high FFA, can be helped to correct the problem

- 乳品業供應鏈管理，控制原物料的品質
The milk industry faces increasing competition, and must have more and more knowledge and control over the raw material



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游離脂肪酸檢測之國際現況 Countries measuring FFA

FFA is today measured in:

檢測游離脂肪酸之主要國家

The Netherlands

Norway

France

Belgium

Japan

Italy

UK

Canada

USA

Denmark

Spain

Brazil

The Czech Republic



FFA included in **Payment Scheme**

FFA含量納入生乳計價系統



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大綱 Outline

- 酪蛋白之應用
Application of casein



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乳蛋白質組成 Composition of milk protein

- 酪蛋白(casein)約佔 80.0 %
 - α 酪蛋白(α casein)
 - α_{s1} 酪蛋白(α_{s1} casein) 、 α_{s2} 酪蛋白(α_{s2} casein)
 - β 酪蛋白(β casein)
 - κ 酪蛋白(κ casein)
- 乳清蛋白質(whey protein)約佔 20 %
 - 白蛋白(albumin)
 - β 乳球蛋白(β -lactoglobulin) 、 α 乳白蛋白(α -lactalbumin) 、 血清白蛋白(serum albumin)
 - 球蛋白(globulin)
 - 免疫球蛋白(immunoglobulin)
- 其他微量蛋白質-如: 乳鐵蛋白質(lactoferrin)

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檢測酪蛋白含量的理由

The reasons for measure casein content in milk

- 可以透過飼養（**營養**）和繁殖（**育種**）的管理，提升牛奶中的酪蛋白含量，因此需要監測酪蛋白含量的變化

The casein content in milk can be influenced through “feed and breed”. Data on casein content is needed to monitor changes



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JERSEY Collection date:12/4/2013



ID	Fat (%)	Protein (%)	Casein (%)	Lactose (%)	SNF (%)	TS (%)
代號	脂肪	蛋白質	酪蛋白	乳糖	無脂固形物	總固形物
98115523	6.74	4.15	3.26	4.43	9.28	16.01
98115515	5.89	3.69	2.88	4.44	8.83	14.73
98115522	9.83	3.39	2.77	4.65	8.73	18.57
99111464	5.22	4.22	3.44	4.84	9.76	14.99
98115519	6.01	3.24	2.54	4.80	8.75	14.75
96116010	5.05	2.91	2.25	4.59	8.20	13.25
99111478	5.13	3.96	3.04	4.59	9.26	14.39
99111453	6.06	3.82	3.02	4.60	9.12	15.18
111807	7.13	3.61	2.90	4.90	9.21	16.33
111805	5.08	3.84	3.13	4.99	9.53	14.61

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大綱 Outline

- 酮症之篩選
Ketosis screening



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何謂酮症 (Ketosis) What is Ketosis

- 酮症為高產牛易發生的代謝性疾病之一，好發於產後六週內
- 因大量泌乳，若攝取的能量無法負擔大量泌乳所需求的熱能，而以體內儲存的脂肪代謝來供給熱能，脂肪代謝過程中會產生酮體，包括丙酮 (acetone)、乙醯乙酸 (acetoacetate) 及 β -羥丁酸 (β -hydroxybutyrate, **BHB**)，而這些酮體須經肝臟代謝，若代謝不完全則留在體內
- **Ketosis, a metabolic disease hitting high yielding dairy cows**
- **Ketosis occurs when energy output (milk production) is too high compared to energy input (feed intake + uptake from fat deposits). In both cases energy uptake from fat deposits becomes too big, the turnover from fat to glucose in the liver too high, and hence acetone and β -hydroxybutyrate (BHB) is excreted as residues**

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酮症的發生率 Incidence of Ketosis

- 臺灣潛在性酮症 (subclinical Ketosis) 佔18.1% (試紙測尿酮體)，同時分析各疾病之相關性，發現第四胃異位與酮症，胎衣滯留與酮症間都有顯著相關 (陳等, 2008)
- 潛在性酮症 (subclinical Ketosis) 發生率3.3-41.9% (Fourichon *et al.*, 1999)
- 加拿大25個乳牛群潛在性酮症發生率8-80% (Duffield, 2001)
- 捷克臨床性酮症 (clinical Ketosis) 發生率1.7% (Fleischer *et al.*, 2001)
- 美國臨床性酮症 (clinical Ketosis) 發生率2-15%，潛在性 (subclinical Ketosis) 者佔9-34% (Ralp *et al.*, 2010)
- 荷蘭泌乳初期牛潛在性酮症 (subclinical Ketosis) 發生率11.2% (Drift, 2013)

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酮症的症狀與篩選 Symptoms and screening of Ketosis

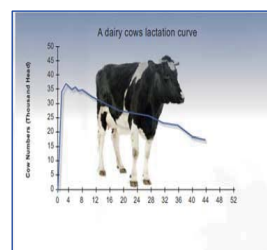
- 會引起泌乳牛乳量下降、不發情等繁殖障礙、食慾減退、削瘦、便秘、眼神呆滯等
Ketosis can cause decreased milk production, reproductive disorders, loss of appetite, slim, constipation, dull eyes, etc. (Primary ketosis, secondary ketosis)
- 雖然死亡率極低，但會使乳牛的泌乳量、乳質、繁殖率降低以及引起生殖系統疾病和內分泌紊亂等多種疾病，導致嚴重經濟損失
Although the mortality rate is very low, but will reduced milk production, milk quality and cause reproductive disorders, endocrine disorders and other diseases. Leading to serious economic losses
- 酮體會出現於血中、尿中及乳液中，國外已發展至少8種簡易試紙法，可測血液、乳液或尿液，一般測BHB及丙酮，較少採用乙醯乙酸
Cow-side tests
- 測DHI乳樣時，同時測乳液中BHB、丙酮
DHI milk analysis

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酮症之篩選指標 Indicators of Ketosis screening

乳成分自動分析儀(Milkoscan FT+) 檢量線特性:

Acetone,	r	0.020	mmol/L
	SEP	0.15	up to 1.5 mmol/L
	(SEPCor	0.07	up to 1.5 mmol/L)
BHB,	r	0.020	mmol/L
	SEP	0.10	up to 0.6 mmol/L
	(SEPCor	0.07	up to 0.6 mmol/L)



***丙酮**含量高於 **0.15 mmol/L** 或 **BHB** 含量高於 **0.10 mmol/L** 表示發生酮症的機率很高
Content of acetone over 0.15 mmol/L or BHB over 0.10 mmol/L means the incidence of Ketosis

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酮症篩選的必要性 Imperative of Ketosis screening

- **DHI 每月檢測數據提供牛群管理人員，在牛隻泌乳初期即可得知是否有酮症發生，及早因應**
Monthly ketosis screening in DHI milk. The herd manager gets a monthly screening of his early lactation cows for ketosis. Cows suffering from ketosis are pointed out and can be treated and one alert should initiate the herd manager to examine all early lactation cows for problems
- **重新檢視及調整乾乳期之牛隻管理流程**
Dry cow management and steaming up procedures should be scrutinised
- **Mike Hutjens (2007) 報告，Cornell 業者乳牛場因每一酮症案例損失達美金145元，其中單獸醫及用藥治療之損失即佔美金50元**



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99175089	3.89	3.73	4.91	9.34	13.23	7.9	0.098	98	2.97	5.58	2.455	1.143	0.961	0.239	0.03	0.01
00175433	6.48	4.24	4.21	9.15	15.64	9.6	0.139	302	3.18	17.67	3.965	2.517	2.129	0.359	0.58	0.22
01160835	4.19	3.27	5.19	9.16	13.35	9.9	0.070	52	2.62	7.77	2.549	1.333	1.126	0.268	0.00	0.00
01160818	3.75	3.07	4.97	8.74	12.50	10.7	0.117	70	2.39	6.69	1.928	1.596	1.413	0.238	0.06	0.00
00175428	1.70	3.39	4.82	8.90	10.61	7.7	0.105	76	2.71	1.99	1.102	0.415	0.407	0.157	0.07	0.00
98174383	3.97	2.52	4.85	8.07	12.05	10.6	0.117	30	1.98	6.81	2.369	1.283	1.062	0.245	0.04	0.02
98174375	4.30	3.82	4.71	9.23	13.53	9.6	0.101	203	3.03	7.00	2.674	1.292	1.147	0.249	0.00	0.00
01160822	3.73	3.02	5.05	8.76	12.49	8.8	0.123	22	2.40	6.28	2.410	1.005	0.846	0.200	0.00	0.00
00175434	3.64	2.93	5.13	8.76	12.40	11.8	0.117	182	2.32	9.02	2.322	0.951	0.748	0.259	0.00	0.00
01161407	5.34	3.65	4.52	8.86	14.21	12.0	0.153	123	2.78	8.07	3.208	1.970	1.836	0.332	0.36	0.10
98174376	5.24	4.67	4.88	10.24	15.49	9.9	0.093	102	3.71	12.03	2.925	1.829	1.570	0.316	0.00	0.00
98174394	5.70	4.41	3.76	8.87	14.57	13.7	0.059	260	3.36	3.90	3.014	2.337	1.823	0.288	0.10	0.06
00175432	3.63	3.39	4.83	8.93	12.56	8.2	0.122	42	2.70	6.57	2.311	0.982	0.835	0.222	0.00	0.00
96172512	4.09	3.48	4.27	8.45	12.54	8.1	0.060	206	2.64	6.32	2.259	1.609	1.312	0.229	0.07	0.00
99175106	3.98	3.27	4.71	8.67	12.65	9.9	0.098	117	2.56	6.49	2.447	1.259	1.038	0.224	0.00	0.00
98174384	4.15	3.22	4.95	8.87	13.02	9.4	0.093	29	2.54	6.18	2.650	1.233	0.923	0.239	0.02	0.02
96172507	4.59	3.64	4.72	9.06	13.64	11.6	0.069	72	2.88	7.71	3.161	1.050	0.849	0.223	0.00	0.00
00175426	3.97	3.69	5.06	9.45	13.42	11.9	0.077	63	3.00	4.68	2.660	0.992	0.938	0.264	0.03	0.00
01160843	4.72	3.43	4.86	8.99	13.71	12.0	0.144	69	2.67	10.03	2.784	1.687	1.394	0.249	0.22	0.06

Jobs

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97176922	4.37	3.35	4.96	9.01	13.38	10.7	0.081	44	2.69	8.44	2.848	1.211	0.998	0.209	0.00	0.00
96171186	4.51	2.78	5.02	8.50	13.01	5.6	0.120	651	2.15	19.22	2.939	1.245	0.941	0.221	0.04	0.06
95172210	3.66	3.39	4.53	8.62	12.27	12.9	0.101	153	2.62	6.54	2.358	0.954	0.817	0.214	0.00	0.00
00172453	5.85	3.64	4.52	8.86	14.71	15.9	0.190	188	2.72	12.66	3.385	2.454	1.896	0.259	0.53	0.11
99175237	5.30	3.94	4.71	9.35	14.66	11.5	0.086	26	3.13	10.71	3.607	1.450	1.236	0.241	0.00	0.00
00172406	4.14	3.38	4.85	8.93	13.07	12.6	0.113	54	2.68	8.81	2.626	1.250	1.032	0.199	0.03	0.00
00172417	4.26	3.44	5.08	9.22	13.48	8.4	0.100	160	2.74	12.77	2.835	1.124	0.865	0.218	0.01	0.01
97176907	4.49	3.22	4.94	8.86	13.35	8.1	0.109	22	2.57	9.71	2.875	1.378	1.107	0.234	0.07	0.00
98173422	5.30	3.43	4.75	8.89	14.19	9.0	0.086	24	2.67	20.40	3.595	1.453	1.173	0.222	0.02	0.03
97176929	5.22	3.44	4.71	8.86	14.07	10.1	0.064	782	2.70	11.23	3.628	1.290	1.114	0.234	0.02	0.03
96171185	4.71	4.13	4.48	9.31	14.02	11.4	0.095	272	3.23	8.20	3.001	1.398	1.137	0.240	0.01	0.00
99175229	3.93	3.23	4.77	8.70	12.63	8.6	0.084	28	2.54	10.30	2.433	1.161	0.942	0.226	0.00	0.00
98173433	3.72	3.29	4.60	8.59	12.31	11.1	0.150	413	2.45	14.10	2.435	1.226	0.800	0.199	0.45	0.11
95171218	4.99	3.88	4.87	9.45	14.44	13.6	0.081	386	3.10	11.26	3.286	1.398	1.117	0.244	0.00	0.00
00172419	4.56	2.78	4.68	8.17	12.73	10.6	0.152	18	2.13	13.03	3.051	1.233	0.912	0.171	0.12	0.08
00172416	4.19	3.14	4.76	8.60	12.79	11.3	0.167	1682	2.37	16.67	2.793	1.245	0.864	0.179	0.04	0.03
97176918	5.02	3.22	5.11	9.02	14.04	4.6	0.115	229	2.30	49.89	4.449	1.700	0.769	0.074	0.25	0.19
00172409	4.61	3.27	5.04	9.01	13.63	7.7	0.125	42	2.58	9.35	3.190	1.277	0.940	0.188	0.04	0.02
98173445	3.46	2.88	5.05	8.63	12.09	9.4	0.109	911	2.28	10.63	2.319	0.885	0.718	0.192	0.01	0.01

Jobs

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Ready NUM

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酪農新挑戰

Challenges in modern dairy farming

- 預防酮症發生
Disease prevention-Ketosis



- 飼養管理
Feeding

調整乳脂肪酸的組成 Fatty acids profile

減少游離脂肪酸量 Decrease content of free fatty acids

提升酪蛋白含量 Increase content of casein

降低酮症發生率 Decrease incidence of Ketosis

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感謝聆聽，敬請指教！

Thank you !



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