出國報告（出國類別：研究）

參加「永續食物生產之農業廢棄物經營(Agriculture Waste Management for Sustainable Food Production)」國際研討會

服務機關：行政院農業委員會畜產試驗所

姓名職稱：林正斌研究員兼組長

派赴國家：馬來西亞

出國期間：民國112年7月9日至7月13日

報告日期：民國 112 年 7 月 21 日

摘要

「永續食物生產之農業廢棄物經營(Agriculture Waste Management for Sustainable Food Production)」國際研討會，係由亞洲太平洋地區糧食肥料技術中心(Food and Fertilizer Technology Center for The Asian and Pacific Region, FFTC)與馬來西亞農業發展研究所(Malaysian Agricultural Research and Development Institute, MARDI)以及菲律賓農業、漁業與資源研究發展委員會(Department of Science and Technology-Philippine council for Agriculture, Aquatic and Natural Resources and Development, DOST-PCAARRD)合辦，此次參與研討會計有馬來西亞、臺灣、韓國、日本、菲律賓、泰國、印尼、越南等 8 國參加，共發表發表 12 篇論文。畜產試驗所飼料作物組林正斌研究員兼組長於本(112)年 7 月 9 日至 13 日赴馬來西亞吉隆坡參加本國際研討會，並於第一項主題-利用廢棄物開發為資源之永續食物生產系統(Utilization of Wastes as an Untapped Resource for Sustainable Food Systems)發表 30 分鐘演講。林正斌研究員兼組長此次受邀出席本研討會並發表「臺灣農業副產物當作動物飼料資源之應用」(Application of Agricultural By-Products as Feed Resources for Livestock in Taiwan)論文，於研討會進行論文發表除展現我國農業副產物飼料資源化應用技術的研發成果，亦與亞太地區國家之研究學者、官員、非政府組織人員、研究人員及產業人士交流，可了解亞太各國畜牧業在農業副產物資源技術現況及相關技術發展並尋求國際合作機會，並增加臺灣研究實力。本次會議後，亦由 FFTC 安排參訪業界參訪，包含金馬崙高原 (Cameron Highlands)的 PJ Eco Recycling Plaza 參訪其零廢棄物技術應用之商店，MARDI 有機農場的試驗成果及 Chitose Oriental Lilyh 園區了解其如何將蔬果等菜餘充分利用，達零廢棄物之作法進行經驗分享及技術交流。

目次

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壹、 目的

本案出國期間自 112 年 7 月 9 日起至 112 年 7 月 13 日止。「Agriculture Waste Management for Sustainable Food Production」 國際研討會係由亞洲太平洋地區糧食肥料技術中心 (FFTC) 與馬來西亞農業發展研究所(Malaysian Agricultural Research and Development Institute, MARDI)以及菲律賓農業、漁業與資源研究發展委員會(Department of Science and Technology-Philippine council for Agriculture, Aquatic and Natural Resources and Development, DOST-PCAARRD)合辦之國際研討會，議程包含了四大主題，包括主題一：利用廢棄物開發為資源之永續食物生產系統 (Session 1：Utilization of Wastes as an Untapped Resource for Sustainable Food Systems), 主持人：Dr. Rosliza Jajuli (Director of Soil Science, Water & Fertilizer Research Centre, MARDI)。主題二：農業廢棄物經營技術之育成 (Session 2：Technological Innovations in Agricultural Waste Management, 主持人：Mohd Shukri Bin Mat Ali (MARDI)。主題三：農業廢棄物經營的經濟及政策觀點(Session 3：Economic and Policy Aspects of Agricultural Waste Management , 主持人：Ms. Ofelia F. Domingo (DOST-PCAARRD)。主題四：主題討論，增加永續及收入之廢棄物經營-挑戰及解決辦法(Session 4：Panel discussion：Waste Management for Increasing Sustainability and Income - Challenges and Solutions, 主持人：Mr. Mohd Rashid Rabu (Director of Socio-Economy, Market Intelligence & Agribusiness Research Centre)。

貳、過程

一、行程

日 期	內 容	地 點	註 解
7/9	臺灣(桃園) -馬來西亞(吉隆坡)	馬來西亞(吉隆坡)	
7/10	參加「Agricultural Waste Management for Sustainable Food Production」研討會並發表論文「臺灣農業副產物當作動物飼料資源之應用」(Application of Agricultural By-Products as Feed Resources for Livestock in Taiwan)」	馬來西亞農業發展研究所（Malaysian Agricultural Research and Development Institute, MARDI）總部 Selangor, Malaysia (吉隆坡)	研討會
7/11	參訪 PJ 生態循環農業廣場 (PJ Eco Recycling Plaza)	金馬崙高原 (Cameron Highlands)	業界參訪
7/12	參訪 MARDI 有機農場、沼氣系統(MARDI Organic Farm & Biogas System) 及參訪 Chitose Oriental Lilyh 循環農業園區	金馬崙高原 (Cameron Highlands)	業界參訪
7/13	回國		

二、議程

2023 MARDI-PCAARRD-FFTC Workshop
Agricultural Waste Management for Sustainable Food Production

Workshop 08：30 – 17：30 (GMT+8), July 10th, 2023

Hybrid mode： Putrajaya Marriott Hotel (onsite) and Webex (online)

Field trip 08：00 – 19：30 (GMT+8), July 11th – 12th, 2023

July 10th, 2023 (Monday), **08：00 – 17：30** (GMT+8) **Workshop**

Time (GMT+8)	Topics and speakers	Note
08：00 – 08：30	Onsite registration and Online login	
	Opening	30 min
08：30 – 08：50	**Welcome and Remarks** MARDI： Dato' Dr. Mohamad Zabawi Bin Abdul Ghani DOST-PCAARRD： Dr. Reynaldo V. Ebora FFTC： Dr. Su-San Chang	*20 min*
08：50 – 09：00	Photo session	*10 min*
09：00 – 09：40	**Keynote lecture** Dr. Loh Soh Kheng (MPOB, Malaysia) **Sustaining Agricultural Production via Waste to Wealth Circular Approach** Moderator： Dr. Tzu-yu Fu (Council of Agriculture, Taiwan)	*40 min (30 min talk +10 min Q&A)*
	Session 1 **Utilization of Wastes as an Untapped Resource for Sustainable Food Systems** Moderator： Dr. Rosliza Jajuli (MARDI, Malaysia)	
09：40– 10：10	Topic 1-1： **Strategies to Recycling Agricultural Byproducts for Increasing Crop Production; Natural Recycling Agriculture and Biochar** Dr. Jin-Hyeob Kwak (Jeonbuk National University, Korea)	*30 min (20 min talk + 10 min Q&A)*
10：10 – 10：40	Topic 1-2： **Application of By-products from Agriculture as Feed Resources for Livestock in Taiwan**	*30 min*

	Dr. Jeng-Bin Lin (Livestock Research Institute, Taiwan)	
10：40 – 11：00	**Tea Break**	*20 min*
11：00 – 11：30	Topic 1-3： **Technological Innovations in Agricultural Waste Management in Malaysia** Dr. Sashikala A/P Maruthai Pillai (MARDI, Malaysia)	*30 min*
11：30 – 12：00	Topic 1-4： **Creation of Food Waste Composting and Recycling Loop in Malaysia** Mr. Shinsuke Takeuchi (KITA, Japan)	*30 min*
	Session 2： **Technological Innovations in Agricultural Waste Management** Moderator： Dr. Teoh Chin Chuang (MARDI, Malaysia)	
12：00 – 12：30	Topic 2-1： **Production Forecasting Systems for Stable Supply and Waste Reduction of Field Vegetables** Dr. Koji Sugahara (NARO, Japan)	*30 min*
12：30 – 13：00	Topic 2-2： **Technological Innovations in Agricultural Waste Management in the Philippines** Ms. Ofelia F. Domingo (DOST-PCAARRD, Philippines)	*30 min*
13：00 – 14：00	**Lunch Break**	*1 hr*
	Session 3： **Economic and Policy Aspects of Agricultural Waste Management** Moderator： Ms. Ofelia F. Domingo (DOST-PCAARRD, Philippines)	
14：00 – 14：30	Topic 3-1： **Community Practice - Sustainable Cassava Value Chain through Knowledge and Technology Transfer in Thailand, Cambodia, Lao PDR, Vietnam, and Myanmar** Dr. Warinthorn Songkasiri (BIOTEC, Thailand) (online)	*30 min*
14：30 – 15：00	Topic 3-2： **Economic Aspect of Sustainable Agricultural Waste Management Strategies in Indonesia： A Case Study of Oil Palm and Sugarcane** Dr. Yusman Syaukat (IPB University, Indonesia)	*30 min*
15：00 – 15：30	Topic 3-3： **Barriers and Policy Gaps for Utilization of Agricultural By-products and Waste for Sustainable Food Production in Vietnam** Dr. Tran Van The (Institute of Agricultural Environment,	*30 min*

	VAAS, Vietnam)	
15：30 – 15：50	**Tea Break**	*20 min*
15：50 – 17：00	**Session 4** **Panel discussion： Waste Management for Increasing Sustainability and Income – Challenges and Solutions** Moderator： Mr. Mohd Rashid Rabu (MARDI, Malaysia) Topic 1： **Integrated Organic Farming (IOF)： Close Loop System/Circular Economy** Prof Anthony Wong (Natural Farming Association Malaysia) Topic 2： **Towards Net-Zero： Taiwan's Pathway to a Carbon Neutral and Circular Agriculture** Dr. Tzu-yu Fu (Counsil of Agriculture, Taiwan)	*1 hr* *10 min*
17：00-17：10	**Summary by FFTC**	*10 min*
17：10 – 17：30	**Closing Remarks** MARDI： Dato' Dr. Mohamad Zabawi Bin Abdul Ghani DOST-PCAARRD： Dr. Reynaldo V. Ebora FFTC： Dr. Su-San Chang	*20 min*

July 11th, 2023 (Tuesday), **Field Trip Program**

Time (GMT+8)	Topics	Note
08：00 – 08：30	Hotel pickup	
08.30 – 09.30	Travel to PJ Eco Recycling Plaza	
09：30 – 11：00	Visit PJ Eco Recycling Plaza	
11：00 – 13：00	Travel to Cameron Highlands	
13：00 – 14：00	Lunch	
14：00 – 17：00	Travel to Cameron Highlands	
17：00 – 20：00	Check-in hotel and free & easy	
20：00 – 21：00	Dinner	

July 12th, 2023 (Wednesday), **Field Trip Program**

Time (GMT+8)	Topics	Note
08：00 – 08：30	Briefing for the waste program at the Hotel	
08：30 – 09：00	Travel to MARDI Cameron Highlands	
09：00 – 09：30	Briefing on MARDI Cameron Highlands Agropark	
09：30 – 10：30	Visit MARDI Organic Farm & Biogas System	

10：30 – 11：00	Coffee break	
11：00 – 11：30	Explore MARDI Agropark	
11：30 – 12：30	Lunch	
12：30 – 13：00	Travel to Chitose Oriental Lily (Vegetables & Fruits shop using zero waste management practices)	
13：00 – 14：00	Visit Chitose Oriental Lily	
14：00 – 14：20	Travel to Compost Centre, Blue Valley	
14：20 – 14：45	Visit Compost Centre (Briefing by Greenviro Sdn. Bhd.)	
14：45 – 15：00	Tea break	
15：00 – 19：00	Travelling back	
19：00 – 19.30	Arrive at MARDI HQ / Hotel	

三、會議內容

此次參與研討會計有馬來西亞、臺灣、韓國、日本、菲律賓、泰國、印尼、越南等 8 國參加，論文發表分成專題演講及四大節主題，共 12 篇研究論文發表。

(一)專題演講：本篇由馬來西亞棕梠油委員會(Malaysia Palm Oil Board)的 Loh Soh Kheng 博士進行專題演講，發表「**Sustaining Agricultural Production via Waste to Wealth Circular Approach**」論文，講述馬來西亞藉由棕梠產業廢棄物的利用，藉以達到氣候循環的永續農業生產的作為。

(二)第一節主題：利用廢棄物開發為資源之永續食物生產系統(Session 1：Utilization of Wastes as an Untapped Resource for Sustainable Food Systems)。第一篇由韓國 Jeonbok National University 的 Jin-Hyeob Kuak 教授發表「**Strategies to Recycling Agricultural Byproducts for Increasing Crop Production; Natural Recycling Agriculture and Biochar**」論文：內容為講述生物碳在韓國增加農作物生產及農副產物在循環農業扮演的角色。第二篇由畜產試驗所的林正斌研究員兼組長發表「**Application of By-products from Agriculture as Feed Resources for Livestock in Taiwan**」論文，內容為講述臺灣的農副產物，如格外品甘藷、鳳梨皮及檸檬皮渣等當畜牧飼料資源化的應用方向及研究成果。第三篇由的馬來西亞農業發展研究所 Sashikala Maruthai Pillai 教授發表「**Technological Innovations in Agricultural Waste Management in Malaysia**」論文，內容為講述馬來西亞在農業廢棄物如蔬果及稻稈等循環應用的技術開發。第四篇由日本 Kitakyushu International Techno-cooperative Association 的 Shinsuke Takeuchi 教授發表「**Creation of Food Waste Composting and Recycling Loop in Malaysia** 」論文，內容講述日本在馬來西亞推展蔬果等廢棄物在循環農業鏈研發的成果。

(三)第二節主題：農業廢棄物經營技術之育成 (Session 2：Technological Innovations in Agricultural Waste Management)。第一篇由日本 National Agriculture and Research Organization 的 Sugahark Koji 教授發表「**Production Forecasting Systems for Stable Supply and Waste Reduction of Field Vegetables**」論文，

內容講述日本生產預測系統在蔬菜田減少農業廢棄物及穩定蔬菜供應的應用。第二篇由菲律賓 Department of Science and Technology-Philippine council for Agriculture, Aquatic and Natural Resources and Development 的 Ofelia F. Domingo 教授發表「**Technological Innovations in Agricultural Waste Management in the Philippines**」論文，內容講述菲律賓在農業廢棄物如水稻稈的研究發展成果，並尋求農業廢棄物達到農業經濟利益、社會接受的技術及策略，直到菲律賓農業及環境問題解決。

(四) 第三節主題：農業廢棄物經營的經濟及政策觀點(Session 3：Economic and Policy Aspects of Agricultural Waste Management)。第一篇由泰國 National Science and Technology Development 的 Warinthorn Songkasiri 教授發表「**Community Practice - Sustainable Cassava Value Chain through Knowledge and Technology Transfer in Thailand, Cambodia, Lao PDR, Vietnam, and Myanmar**」論文，內容講述樹薯的永續生產鏈技術輸出在泰國、柬埔寨、佬沃、越南及緬甸的應用及支援，並協助如樹薯之全球綠色食物資源推展至全球市場。第二篇由印尼 Department of Resource and Environment Economics 的 Yusman Syaukat 教授發表「**Economic Aspect of Sustainable Agricultural Waste Management Strategies in Indonesia：A Case Study of Oil Palm and Sugarcane**」論文，內容講述印尼在油棕及甘蔗作物在永續農業廢棄物經濟面向方面的研發策略。第三篇由越南 Institute for Agricultural Environment 的 Tran Van The 教授發表「**Barriers and Policy Gaps for Utilization of Agricultural By-products and Waste for Sustainable Food Production in Vietnam**」論文，內容講述越南農業副產物及廢棄物在永續食物生產利用的政策。

(五) 第四節主題：主題討論–增加永續及收入之廢棄物經營-挑戰及解決辦法(Session 4：Panel discussion：Waste Management for Increasing Sustainability and Income – Challenges and Solutions。由馬來西亞 Market Intelligence & Agribusiness Research Centre 的 Mohd Rashid Rabu 主任擔任主持人，邀請業者 Integrate Organic Farming 集團的執行長 Anthony Wong 發表「**Integrated Organic Farming (IOF)： Close Loop System/Circular Economy**」及農

委會淨零辦公室傅子煜執行秘書發表「**Towards Net-Zero：Taiwan's Pathway to a Carbon Neutral and Circular Agriculture**」報告，並討論為提升永續並增加收入，農業廢棄物經營所面臨的挑戰及解決辦法。

參、心得與建議

（一）藉此次奉派參加FFTC在馬來西亞舉辦的「**Agricultural Waste Management for Sustainable Food Production**」機會，瞭解各國循環農業、農業副產物及廢棄物的研究議題及方向，同時也觀摩各國相關領域之研究設備，積極認識各國研究人員及研究團隊，藉此讓本所相關團隊及研究人員與各國技術交流，同時並拓展及推動未來更多國際合作之機會，並由此次研討會的技術交流及精進科技研發，達成與國際循環農業及碳排淨零政策接軌。

（二）此次研討會由演講者的報告內容及與會者彼此間的溝通交流中發現，目前東南亞各國均面臨生產成本高漲、農業副產物及廢棄物對環境、經濟及社會造成的衝擊與影響，因此紛紛將研究著重在農副產物再利用、提升產量及減少格外品之生產預估模式之研發及循環農業之推展策略等方向。而國內農業目前所面臨的農業生產成本高漲及廢棄物處理亦面臨相同問題。因此，農業廢棄物及副產物再利用的研發仍值得持續推展。

（三）參加國際會議之研究人員了解國際當前之研究方向及研究結果，作為自身研究方向之參考，參加國際會議亦可認識他國研究學者。因此，參加 FFTC會議能瞭解亞澳地區小農之發展及國際廢棄物運用動向，亦建議相關單位應多提供補助研究同仁出國發表之經費並鼓勵同仁多出國發表及參與國際合作，提升國內畜產及農業資源再利用之研究水準。

肆、口頭報告簡報

Application of By-Products from Agriculture as Feed Resources for Livestock in Taiwan

Jeng-Bin Lin

Livestock Research Institute , Council of Agriculture, Taiwan, Republic of China (ROC)

July 10,2023

Introduction

- According to the paper since 2011 to 2021 of National Statistics ROC (Taiwan) (National Statistics, 2021), for the past ten years, there were average 5 million tons of agricultural wastes would be produced each year in Taiwan.
- A lots of agricultural wastes from agriculture and food processing and agricultural by-products those would be treated by made for manure (53.2%) or clover up in the soil (26.1%).

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Introduction

- There are 50 % self-sufficiency of forage in Taiwan, the others forage are input from another countries .
- In this article, the ensiling techniques will be addressed for fruit pill pomace or sub-quality of agricultural by-products and then, the efficacy of the silage made by those agricultural by-products or wastes to feed dairy cows in Taiwan will be discussed..

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Materials	Mixture	Ensiling
Sweep potato	wheat bran	yes
Pineapple	wheat bran	yes
Pomelo	napier grass	yes
Pomelo	—	yes
Banana	—	yes
Orange	wheat bran、pangola grass	yes
Red pitaya	—	no
Cabbage	—	no

Materials	Mixture	Ensili
Sweep potato vine, leaf	sweet potato	yes
Pineapple pill	wheat bran	yes
Pineapple pill	rice straw	yes
Lemon pill promace	napier grass	yes
Lemon pill promace	wheat bran	yes
Kumquat pill promace	napier grass	yes
Grapefruit pill promace	wheat bran	yes
Tomato pomace	—	yes

pineapple pill & wheat bran or pangola grass for dairy cows

pineapple pill & wheat bran for dairy goats

pineapple pill & rice straw for dairy cows

pineapple pill & spent mushroom substrate for dairy cows and goats

silage of rice straw for dairy goats

orange & pangola grass for beef cattle

silage of tomato pill pomace for dairy cows and goats

silage of banana for dairy cows

silage of pomelo for beef cattle

silage of pomelo & napier grass for beef cattle

Introduction

- Available by-products locally produced feed resources for food safety and sustainable environment is important.
- This study is introduced by-products utilization research work.

silage

- sub-quality sweet potato (SSP)
- sweet potato vine and leaf (SPL)
- residue of fruit juice：orange, grapefruit, kumquat, lemon and pineapple

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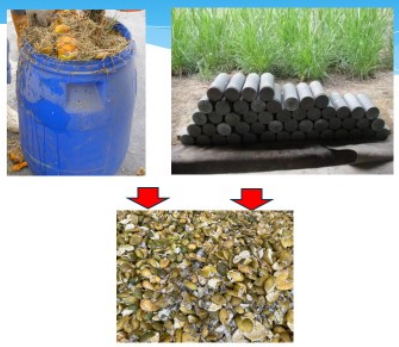
I. Evaluation of silage quality



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i. Sweet potato

Table 1. Composition analysis of sweet potato and vine and leaf silage

Combination	DM	CP	NDF	ADF	IVDMD	Ca	P	pH	Flieg's score
SSP	24.00	3.96	7.11	6.43	92.94	0.22	0.24	3.67	91
SPL	21.96	7.66	40.98	33.60	61.80	1.84	0.44	4.25	82
SPL 1 : SSP 1	21.53	5.73	23.67	18.93	79.94	1.06	0.35	3.89	79
SPL 2 : SSP 1	21.29	5.29	27.39	22.71	74.86	1.26	0.38	3.81	86
SPL 3 : SSP 1	21.07	4.85	29.52	24.44	73.61	1.43	0.40	4.01	94
SPL 1 : SSP 2	21.57	6.03	21.63	16.98	79.36	0.89	0.36	3.78	89
SPL 1 : SSP 3	21.31	6.72	16.59	14.52	83.97	0.74	0.33	3.72	96

- sub-quality sweet potato (SSP), sweet potato vine and leaf (SPL)

The Flieg's scores divides into 5 grades, including:
below 20, very low quality
21-40, low quality
41-60, medium quality
61-80 , good quality
81-100 , very good quality (McCullough, 1978; Kilic, 1986).

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ii. Oranges

Table 2. Analysis of components of oranges peel pomace silage

Combination	DM	CP	NDF	ADF	IVDMD	pH	Flieg's score
OP	16.94	9.68	17.43	15.50	91.54	3.53	99
OP 9 : WB 1	21.92	13.71	21.46	14.02	86.18	3.57	98
OP 8 : WB 2	29.79	15.55	23.46	13.12	85.20	3.75	97

- orange pill pomace (OP), wheat bran (WB).
- 81-100 , very good quality (McCullough, 1978; Kilic, 1986).

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iii. Grapefruit

Table 3. Analysis of components of grapefruit peel pomace silage

Combination	DM	CP	NDF	ADF	IVDMD	pH	Flieg's score
GP	17.87	7.30	17.29	13.94	92.46	3.46	90
GP9 : WB 1	23.89	12.03	21.07	13.4	87.79	3.49	89
GP 8 : WB 2	28.82	15.34	24.94	13.27	83.55	3.57	97
GP 7 : WB 3	35.02	17.74	27.6	13.09	81.28	3.78	97

- Grapefruit pill pomace (GP), wheat bran (WB).
- 81-100 , very good quality (McCullough, 1978; Kilic, 1986).

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iv. Kumquat

Table 4. Analysis of components of kumquat peel pomace silage

Combination	DM	CP	NDF	ADF	IVDMD	pH	Flieg's score
KP 6 : NP 3 : WB 1.5	27.94	15.02	38.13	19.86	72.96	3.93	76
KP 3 : NP 6 : WB 1.5	28.66	14.35	45.16	24.95	64.30	3.96	82
KP 5 : NP 5 : WB 1.5	28.85	14.28	44.96	24.86	64.69	3.92	77

◆Kumquat peel (KP),
◆Napier grass Taishiu cv. No. 2 (NP)
◆wheat bran (WB)
◆61-80 , good quality, 81-100 , very good quality (McCullough, 1978; Kilic, 1986).

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v. Lemon

Table 5. Analysis of components of lemon peel pomace silage

Combination	DM	CP	NDF	ADF	IVDMD	pH	Flieg's score
LP	18.43	9.79	27.62	22.25	94.46	3.77	81
LP9 : WB 1	21.09	14.92	31.71	17.25	84.44	3.82	55
LP 7 : WB 3	33.98	17.63	35.49	15.05	78.70	3.96	54
LP 6 : NP 3 : WB 1.5	28.82	13.75	41.01	23.65	72.92	3.93	66
LP 3 : NP 6 : WB 1.5	28.99	13.26	50.98	29.49	62.54	3.97	77
LP5 : NP 5 : WB 1.5	27.92	13.12	44.31	25.43	70.13	3.85	80
LP 6 : NP 3 : WB 1.5	28.82	13.75	41.01	23.65	72.92	3.93	66
LP 3 : NP 6 : WB 1.5	28.99	13.26	50.98	29.49	62.54	3.97	77

◆ lemon pill (LP)
◆Napier grass Taishiu cv. No. 2 (NP)
◆wheat bran (WB)
◆41-60, medium quality, 61-80 , good quality ,81-100 , very good quality (McCullough, 1978; Kilic, 1986).

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vi. Pineapple

Table 6. Analysis of components of pineapple peel silage

Combination	DM	CP	NDF	ADF	IVDMD	pH	Flieg's score
PP	10.44	5.53	46.43	22.47	80.00	3.50	88
PP : RS = 3 : 1	30.27	7.31	68.38	48.52	38.75	3.67	72
PP : RS = 4 : 1	26.00	7.56	68.15	44.04	37.47	3.65	77
PP : RS = 5 : 1	23.29	7.40	66.43	45.61	41.69	3.62	73
PP : RS = 6 : 1	21.72	7.63	66.29	41.86	41.98	3.59	73
PP : RS = 7 : 1	19.35	8.19	66.29	40.67	40.97	3.51	77
PP : RS = 8 : 1	17.04	7.98	66.28	41.30	44.26	3.55	70
PP : RS = 9 : 1	15.85	8.24	64.83	40.19	47.32	3.51	70
PP : RS = 10 : 1	15.45	8.21	64.03	40.11	45.59	3.55	68

◆ Pineapple pill (PP) ,Rice straw (RS)
◆ 61-80 , good quality ,81-100 , very good quality (McCullough, 1978; Kilic, 1986).

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II. Agricultural product processing residues ~ application of peel and pomace

Pineapple Food Processing Factory

- By-products (peel) account for 57% of the original fruit

Lemon juice Processing Factory

- By-products (peel and pomace) account for 30% of the original fruit

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Table 7. Analysis of pineapple (PP) or lemon (LP) silage

Material	DM	CP	NDF	ADF	IVDMD	Flieg's score
PP	10.44	5.53	46.43	22.47	79.69	88
LP	18.43	9.79	27.62	22.25	94.46	81

◆ pineapple peel (PP)

◆ lemon peel pomace (LP)

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i. Pineapple pill feeding trial of dairy cow

Pineapple pill 7 +

Rice straw 1

Sausage silage bags of pineapple peel with rice straw silage (PPR)

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- 40 heads dairy cows, divide into four groups, and feed pineapple rice straw silage diet containing 0, 3, 6, and 9%, respectively.
- Feeding trial was conducted twice for 28 days each, analysis the lactation performance, milk quality of dairy cows, and to evaluate the appropriate amount of silage in the ration of dairy cows.

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Table 8. The feed formula of silage on pineapple pills mixed with rice straws (% of dry matter)

Ingredients	The amount of PPR added to the diet			
	Control	3%	6%	9%
	(% of Dry matter)			
Corn silage	26.60	26.47	26.24	26.07
Pangola hay	4.63	2.99	1.60	0
Alfalfa hay	7.02	6.99	6.93	6.88
Brewers' grains	6.38	6.35	6.09	6.26
Sorghum distiller's grain	0.75	2.54	1.26	0
Soybean hulls	14.21	14.14	14.01	13.92
pineapple peel and rice straw silage	0.00	3.07	6.09	9.07
WB	4.74	4.72	4.68	4.65
Grain concentrate	35.67	34.73	33.1	33.15

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Table 9. Effect of supplementation of pineapple pills mixed with rice straws in diets on lactating performance of dairy cows

Feed efficiency	Diet treatments				Contrast effect
	Control	3%	6%	9%	
DMI, kg/d	18.1	17.8	18.7	17.7	NS
Milk production, kg/d	22.5	23.8	23.2	23.5	NS
Feed efficiency (milk/intake)	1.25	1.34	1.24	1.33	NS
Milk quality	Milk composition				
Milk fat, %	3.89	3.65	3.86	3.79	NS
Milk protein, %	3.44	3.38	3.48	3.34	NS
Milk lactose, %	4.73	4.76	4.72	4.86	NS
SNF, %	8.89	8.83	8.89	8.91	NS
MUN, mg/dL	12.5	11.9	12.8	12.4	NS

Contrast effect: control vs. added PPR , NS (P>0.05)

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Table 10. Evaluation of economic benefits of adding pineapple peel and rice straw silage to dairy cows

Economic benefits	Diet treatments			
	Control	3%	6%	9%
Feed price NT$/DM/kg	11.63	11.80	11.93	12.10
Feed cost NT$/head/day	211	211	223	214
Unit price of milk NT$/kg	28.99	28.61	28.99	28.80
Milk income NT$/head/day	652	681	673	677
Crude income NT$/head/day	441	470	450	463
	(100%)	(106%)	(102%)	(105%)

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summary

- The mixed silage of pineapple peel and rice straw were fed to dairy cows, and the effect of adding 9% of the diet to the dry basis is still good.
- Therefore, pineapple peel can be used as a good source of feed ingredients for dairy cows.

ii. Lemon pill promace feeding trial of dairy cow

18 heads dairy cows, divide them into three groups

- Control
- LP : NP 5:5 silage
- LP : NP 3:7 silage

◆ lemon pill promace (LP) ◆Napier grass Taishiu cv. No. 2 (NP)

- 40 heads dairy cows, divide to four groups, and feed lemon pill napier grass silage diet containing 5:5 and 3:7 , respectively.
- Feeding experiments were conducted twice for 28 days each, to measure the lactation performance and milk quality of the cows, and to evaluate the appropriate amount of silage in the ration of dairy cows.

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Table 11. Silage quality of different combination ratio mixed lemon pill pomace with napier grass

	LP : NP 5:5 silage	LP : NP 3:7 silage
pH	3.30	3.20
Flieg's score	72	96

NP LP

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Table 12. The Effects of adding lemon peel pomace and Napier grass mixed for silage on lactation performance of dairy cows

	Control	LP : NP 5:5 silage	LP : NP 3:7 silage
n	6	6	6
DMI, kg/d	22.5	21.9	21.3
Milk production, kg/d	23.1	22.7	21.9
Feed efficiency(milk/intake)	1.03	1.04	1.02
Milk composition			
Milk fat, %	3.89	3.87	3.91
Milk protein, %	3.37	3.39	3.37

No significance difference (P > 0.05)

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Table 13. Evaluation of economic benefits of lemon peel pomace and napier grass mixed silage to dairy cows

	Control	LP : NP 5:5 silage	LP : NP 3:7 silage
Feed price NT$/DM/kg	12.46	12.61	12.60
Feed cost NT$/head/day	280	276	268
Unit price of milk NT$/kg	28.8	28.8	28.99
Milk income NT$/head/day	665	654	635
Crude income NT$/head/day	385	378	367
Feed price NT$/DM/kg	100	98.2	95.3

The crude income of the diet with more proportion of lemon peel promace is not lower than that of the diet with more NP

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Summary

- Results showed that after deducted the feed fee, adding silage of lemon pill pomace mixed with napier grass at the ratio of 5:5 and 3:7 ratio decreased the crude income by 1.8% and 4.7%, respectively.
- The result also showed that the feeding efficiency of lemon pill pomace silage was similar to napier grass.
- Therefore, lemon peel pomace can be used as a good source of feed ingredients for dairy cow.

Silage storage method

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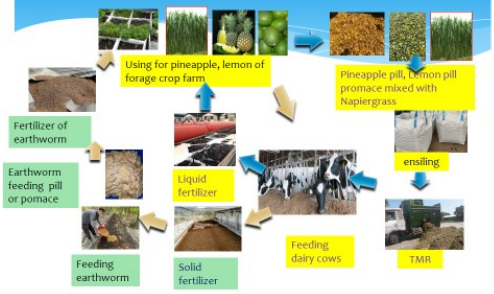
Conclusion

Using the ensiling technique of agricultural by-products and wastes is a recycling methods, those might be set up an agricultural recycling model and save feed cost.

The new model of sustainable agriculture of by-products in Taiwan



Thank you for your attention

corn spike-stalk

orange

sunflower

伍、發表報告內容

Application of Agricultural By-Products as Feed Resources for Livestock in Taiwan

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ABSTRACT

Most of the feed ingredients for Taiwan livestock are imported. On the other hand, an abundant of residues generated from agriculture and food processing requires additional costs for disposal. Utilizing local available agricultural by-products as feed resources is crucial for food security and sustainable environment. This study aimed to investigate the utilization of agricultural by-products for livestock feeds. Sub-quality sweet potato, sweet potato vine, sweet potato leaf, and residue of fruit juice were conducted by mixing these by-products with other dry fibrous sources such as rice straw, wheat bran, or Napier grass to make silage. Napier grass Taishiu cv. No. 2 is a very popular and important forage crop in Taiwan. The quality of the silage made by the mixture of sweet potato and sweet potato leaf was very good in terms of Flieg's score over 80 point. Silage made from orange, grapefruit, kumquat, lemon pill pomace, or pineapple peels also had excellent Flieg's score and high dry matter digestibility in vitro. Silage made from pineapple peel mixed with rice straw (pineapple pill： rice straw, 10： 1) (PPRS) was fed to dairy cows. The diet contained 9% (on a dry matter basis) of PPRS could maintain milk yield and milk fat percentage, showed no significant difference compared with the control diet without PPRS. Another case involved feeding dairy cows with silage made from lemon peel pomace and Napier grass silage (5：5 or 3：7 w/w) (LPNG). The cows accepted the diet when 10% dry matter of LPNG was added. There was no significant difference compared with control diet when 10% LPNG was added to a diet with a ratio of 5： 5 or 3：7. The milk yield of the cows fed diet with high ratio of lemon peel (5：5) was similar to the cows fed diet with high ratio of Napier grass (3：7), indicated that the feeding effect of lemon peel pomace is comparable to that of Napier grass Taishiu cv. No. 2. Further studies are needed to confirm proper preservation and wrapping techniques, efficient transportation, nutritional balance knowledge and cost when applying the ensiling technique to utilize those agricultural by-products.

Keywords： By-Products, Agriculture, Feed Resources, Livestock.

INTRODUCTION

Those agricultural wastes include agricultural by-products and processing by-products. Agricultural by-products are the leftovers of crops after harvest, which includes rice straw, wheat bran, sub-quality sweet potato, sweet potato vine and sweet potato leaf. Agricultural processing by-products are the residue after the procession of agricultural products, which includes lemon peel pomace, grapefruit peel pomace, kumquat peel pomace and pineapple peel. Such agricultural by-products and wastes were mainly treated by mean of manure (53.2%) or clover up in the soil (26.1%) in

Taiwan. However, due to the high humidity and temperature in Taiwan, the pile up of agricultural by-products might produce odorous smell and flies by the high environmental temperature that results in a problem of environmental hygiene and air pollution. In addition, extra cost is required for disposal. Therefore, finding an available method to treat these agricultural by-products and wastes is an important aim in Taiwan. The method might be expected to achieve the aims of increase using value of the by-products and decrease the waste quantities as well. Using ensiling technique could transfer the agricultural by-products and wastes to feed resources since such materials are still rich of nutrient for potential feedstuff. Apply the ensiling technique to innovate new feed resources are crucial aims for the decrease of feed cost, keeping feed security, stabilizing feed supply, increase of income and keeping a sustainable environment in Taiwan. Such technique could decrease the environmental pollution from the abandoned materials. It is also beneficial to reduce the usage of concentrate and roughage, reduce the dependence on import feedstuffs and cost, and hence increase the income of livestock industry. The production of agricultural by-product is seasonal that causes the problem to maintain stable supply for feedstuff utilization. Such problem causes low will of farmers to use the agricultural by-product as feedstuff. According to that, ensiling techniques might be a good method for the preservation of agricultural by-product and maintaining stable supply.

In this article, the ensiling techniques will be addressed for fruit pill pomace or sub-quality of agricultural by-products and then, the efficacy of the silage made by those agricultural by-products or wastes to feed dairy cows in Taiwan will be discussed.

MATERIALS AND METHODS

I. Evaluation of quality on different combinations of agricultural by-product or waste for silage

In this study different kinds of agricultural by-products or wastes dependent on different seasons were selected to make silage. Mixture of different material combinations was compressed inside the plastic tube. Three replicates of each combination were made and those materials were preserved for one month for ensiling.

After the end of ensiling, silage sample was collected for the test of silage quality. Sampled 10 g of silage sample and added 200 mL of distilled water then filtered by filter paper after stirred and broke evenly. The PH of the filtered solution was measured by pH meter. The solution then was filtered by 0.45 μm PTFE membrane. The lactic acid, acetic acid, propionic acid and butyric acid of the solution were analyzed by high performance liquid chromatography (model L-2450, HITACHI, Japan) by the method of Fan *et. al.* (2018). Evaluation of the quality grade of silage was based on Flieg's score which represents the percentage of the acetic acid, propionic acid and butyric acid in silage. The Flieg's scores divides into 5 grades, including below 20, 21-40, 41-60, 61-80 and 80-100 point, the meanings of silage quality are very low quality, low quality, medium quality, good quality and very good quality, respectively (McCullough, 1978; Kilic, 1986).

Silage sample was dried in oven at 55°C for 48 hours. After ground by 1 mm screen, the crude protein was analyzed by Kjeldahl method (AOAC, 2000). The neutral detergent fiber and the acid detergent fiber was analyzed by Ankom 200 fiber analyzer (ANKOM, 2006, ANKOM Technology Corp., Fairport, NY). The dry matter digestibility in vitro was analyzed by the modified method of Lee and Shiao (2007).

Different kinds of by-product silages were mixed to investigate the best combination condition of silage mixture in pilot test. The test result was regarded as a reference of silage source for animal experiment.

II. Evaluation of silage of pineapple pills mixed with rice straws for feeding dairy cows

Pineapple pills mixed with rice straws by the combinative ratio of 10：1 for ensiling. 40 dairy Holstein cows with daily milk yield above 20 kg were randomly selected and assigned into 4 treatments as 0, 3, 6 and 9% silage of feed formula and 10 dairy cows for each treatment. Experiment was carried out twice with 28 days each. The milk production, milk content and economic efficiency was analyzed to evaluate the appropriate usage amount of pineapple-pills-rice-straws silage for dairy cows after 28 days feeding trial. Feed formula of silage with other feedstuff and roughage was shown in Table 1.

Table 1. The feed formula of silage on pineapple pills mixed with rice straws (% of dry matter)

Material	Control	3%	6%	9%
Corn silage	26.6	26.5	26.2	26.1
Pangola grass hay	4.6	3.0	1.6	0
Alfalfa hay	7.0	7.0	6.9	6.9
Wet brewer's grains	6.4	6.4	6.1	6.3
Sorghum distiller’s grains	0.75	2.5	1.3	0
Soy bean hull pellet	14.2	14.1	14.0	13.9
Content of silage	0.0	3.1	6.1	9.1
Wheat bran	4.7	4.7	4.7	4.7
Concentrate[1,2]	35.7	34.7	33.1	33.2
Total	100.0	100.0	100.0	100.0

[1] Concentrate included corn ground 52.0%, soybean meal (43%) 34.7%, fish meal (65%) 3.3%, molasses 2.9%, salt 0.72%, limestone 2.15%, dicalcium phosphate 0.45%, potassium carbonate 0.88%, sodium bicarbonate 1.75%, urea 0.43%, vitamin premix 0.5%, and mineral premix 0.22%. (as fed basis)

[2] Each gram of vitamin premix contained 10,000 IU of vitamin A, 2,000 IU of vitamin D3, and 55 IU of vitamin E. Each kilogram of mineral premix contained 16 gm of Cu, 15 gm of Mn, 0.2 gm of Co, 53 gm of Zn, 1 gm of I, and 0.5 gm of Se.

III. Evaluation of silage of lemon pill pomace mixed with napier grass for feed dairy cows

Lemon pill pomaces were from fruit processing factory of Pingtung county, Taiwan. The lemon pill pomaces was mixed with 12 weeks after regrowth of napier grass for ensiling and those of combinative ratio were 5：5 and 3：7, respectively. Feed formula of silage on lemon pill pomace mixed with napier grass was shown in Table 2. There were18 dairy cows at late lactation period with daily milk yield above 20 kg were randomly selected and assigned into 3 treatments as control and different mixed ratio of lemon pill pomace with napier grass at 5：5 and 3：7, respectively. Experiment was carried out for 28 days. Daily feed intake and milk yield of each cow was measured. The raw milk from the last three day of collection was collected for the analysis of milk composition and economic efficiency by DHI data base.

Table 2. The feed formula of silage on lemon pill pomace mixed with napier grass (% of dry matter)

Material	Control	Lemon pill pomace mix with napier grass (5：5)	Lemon pill pomace mix with napier grass (3：7)
Corn silage	29.38	19.45	19.45
Pangola grass	4.58	4.55	4.55
Alfalfa hay	11.58	11.5	11.5
Wet Brewer's grains	5.34	5.61	5.46
Soy bean hull pellet	16.4	16.29	16.29
Wheat bran	4.69	4.66	4.66
Lemon pill silage (5：5)	0	10.11	0
Lemon pill silage (3：7)	0	0	10.27
Concentrate	28.03	27.83	27.82
Total	100.0	100.0	100.0

[1] Concentrate included corn ground 57.0%, soybean meal (43%) 28.0%, fish meal (65%) 2.5%, soybean oil 1%, molasses 3%, salt 0.60%, limestone 3.0%, dicalcium phosphate 0.30%, potassium carbonate 1.0%, sodium bicarbonate 1.8%, magnesium oxide 0.6%, urea 0.3%, vitamin premix 0.5%, and mineral premix 0.4%. (as fed basis)

[2] Each gram of vitamin premix contained 10,000 IU of vitamin A, 2,000 IU of vitamin D3, and 55 IU of vitamin E. Each kilogram of mineral premix contained 16 gm of Cu, 15 gm of Mn, 0.2 gm of Co, 53 gm of Zn, 1 gm of I, and 0.5 gm of Se.

RESULTS AND DISCUSSION

I. Evaluation of quality on different agricultural by-product or waste combinations for silage

i. Sweet potato

Sweet potato products are more and more popular in human food markets. Due to strict quality control, it is estimated that 15% of sweet potatoes are discarded because of their shapes or sizes are not to comply with a standard. This off part resulted in proximately 36,254 tons per year in Taiwan. Sweet potato provides starch like corn. It was aimed to explore the proper ensiling technique for sub-quality sweet potato and also the proper formulation way in diets for ruminants so as to promote its recycling application. The silage quality of different mixture ratio of sub-quality sweet potato and sweet potato leaves was tested. The silage made by sweet potato vine mixed with sub-quality sweet potato at combination ratio 1：3 got the highest quality of Flieg's score when the Flieg's score of those silages was all over 80 points. After one month of ensiling, the silage quality of Flieg's score of sweet potato vine was 82, but white fungus was found. It might be the results of less tightness or compression during ensiling. Using sub-quality sweet potato mixed with fruit pill pomace for ensiling, the IVDMD value of silage could reach 90%, but the IVDMD value of another silages were 60% when mixed with wheat bran or napier grass (Table 3). The quality of silage made by sweet potato vines with sub-grad sweet potato mixture is good, and the remaining materials after the sampling were completely consumed when fed to Taiwanese Yellow Cattle. Therefore, in the future, silage made by the sub-grade sweet potato with sweet potato vine mixture will be determined by animal experiments as raw feed materials for ruminant animal to evaluate the feasibility of turning waste materials into feed.

Table 3. Composition analysis of sweet potato, vine and leaf silage

Combination	DM	CP	NDF	ADF	IVDMD	Ca	P	pH	Flieg's score
SSP[1]	24.00	3.96	7.11	6.43	92.94	0.22	0.24	3.67	91
SPL	21.96	7.66	40.98	33.60	61.80	1.84	0.44	4.25	82
SPL 1：SSP 1	21.53	5.73	23.67	18.93	79.94	1.06	0.35	3.89	79
SPL 2：SSP 1	21.29	5.29	27.39	22.71	74.86	1.26	0.38	3.81	86
SPL 3：SSP 1	21.07	4.85	29.52	24.44	73.61	1.43	0.40	4.01	94
SPL 1：SSP 2	21.57	6.03	21.63	16.98	79.36	0.89	0.36	3.78	89
SPL 1：SSP 3	21.31	6.72	16.59	14.52	83.97	0.74	0.33	3.72	96

[1] SSP： sub-quality sweet potato, SPL： sweet potato leaf and vine.
[2] DM： dry matter, CP： crude protein, NDF： neutral detergent fiber, ADF： Acid detergent fiber, IVDMD： *in vitro* dry matter digestibility, Ca： calcium, and P： phosphate.

ii. Orange pill pomace, kumquat pill pomace and grapefruit pill pomace

Silage made from orange pill pomace, kumquat pill pomace and grapefruit pill pomace mixed with wheat bran was evaluated. The Flieg's score of silage made of orange and grapefruit pill pomace mixed with wheat bran was over 90 point after ensiling for one month later and the quality was evaluated as excellent. However, the silage made by grapefruit pill pomace mixed with wheat bran at the ratio of 7：3 maintained good quality, while the quality of the silage made by orange pill pomace mixed with wheat bran at the ratio of 7：3 slight decreased to the bottom line of good quality. The silage score of kumquat pill pomaces mixed with wheat bran or napier grass evaluated above 76 point (Table 4).

Table 4. Analysis of components of oranges, grapefruit, and kumquat peel silage

Combination	DM	CP	NDF	ADF	IVDMD	pH	Flieg's score
OP	16.94	9.68	17.43	15.50	91.54	3.53	99
OP 9：WB 1	21.92	13.71	21.46	14.02	86.18	3.57	98
OP 8：WB 2	29.79	15.55	23.46	13.12	85.20	3.75	97
OP 7：WB 3	31.50	16.83	25.40	12.75	84.98	3.94	62
GP	17.87	7.30	17.29	13.94	92.46	3.46	90
GP9：WB 1	23.89	12.03	21.07	13.40	87.79	3.49	89
GP 8：WB 2	28.82	15.34	24.94	13.27	83.55	3.57	97
GP 7：WB 3	35.02	17.74	27.6	13.09	81.28	3.78	97
KP 6：NP 3：WB 1.5	27.94	15.02	38.13	19.86	72.96	3.93	76
KP 3：NP 6：WB 1.5	28.66	14.35	45.16	24.95	64.30	3.96	82
KP 5：NP 5：WB 1.5	28.85	14.28	44.96	24.86	64.69	3.92	77

[1] OP： peel of orange, GP： peel of grapefruit, KP： peel of kumquat, NP： Napier grass Taishiu cv. No. 2, WB： wheat bran.
[2] DM： dry matter, CP： crude protein, NDF： neutral detergent fiber, ADF： Acid detergent fiber, IVDMD： *in vitro* dry matter digestibility.

iii. Lemon pill pomace

Using the lemon pill pomace alone for ensiling that the silage quality was 81 point of Flieg's score (Figure 1). When the lemon pill pomace mixed with wheat bran the silage quality would be decreased to acceptable grade, while those lemon pill pomace mixed with wheat bran or napier grass the quality of silage was evaluated as good grade. The silage score of lemon pill pomace was lower than those of the orange, kumquat and grapefruit pill pomace silage score. By the same adjustment material and formula ratio, the silage quality of kumquat pill pomace was slight higher than lemon pill pomace (Table 5).

Figure 1. Silage of lemon pill pomace (left) and pineapple pill (right).

Table 5. Analysis of components of lemon peel silage

Combination	DM	CP	NDF	ADF	IVDMD	pH	Flieg's score
LP	18.43	9.79	27.62	22.25	94.46	3.77	81
LP9：WB 1	21.09	14.92	31.71	17.25	84.44	3.82	55
LP 7：WB 3	33.98	17.63	35.49	15.05	78.70	3.96	54
LP 6：NP 3：WB 1.5	28.82	13.75	41.01	23.65	72.92	3.93	66
LP 3：NP 6：WB 1.5	28.99	13.26	50.98	29.49	62.54	3.97	77
LP5：NP 5：WB 1.5	27.92	13.12	44.31	25.43	70.13	3.85	80

[1] LP： peel of lemon, NP： Napiergrass Taishiu cv. No. 2, WB： wheat bran.

[2] DM： dry matter, CP： crude protein, NDF： neutral detergent fiber, ADF： Acid detergent fiber, IVDMD： *in vitro* dry matter digestibility.

iv. Pineapple pill

Using the pineapple pill pomace alone for ensiling that the silage quality was 88 point of Flieg's score with good quality (Figure 1). The IVDMD of pineapple silage

was 80%, which was lower than that 90% of other fruit pomace silage. From the results of the silage made by rice straw and pineapple pill pomace showed those of the dry matter, neutral detergent fiber, acid detergent fiber and pH would increase and decrease IVDMD when increase the ratio of the rice straw in the silage. All of the Flieg's scores of the different silages with pineapple pill treatments reached above 68 points and regarded as good quality grade (Table 6).

Table 6. Analysis of components of pineapple peel silage

Combination	DM	CP	NDF	ADF	IVDMD	pH	Flieg's score
PP	10.44	5.53	46.43	22.47	80.00	3.50	88
PP：RS = 3：1	30.27	7.31	68.38	48.52	38.75	3.67	72
PP：RS = 4：1	26.00	7.56	68.15	44.04	37.47	3.65	77
PP：RS = 5：1	23.29	7.40	66.43	45.61	41.69	3.62	73
PP：RS = 6：1	21.72	7.63	66.29	41.86	41.98	3.59	73
PP：RS = 7：1	19.35	8.19	66.29	40.67	40.97	3.51	77
PP：RS = 8：1	17.04	7.98	66.28	41.30	44.26	3.55	70
PP：RS = 9：1	15.85	8.24	64.83	40.19	47.32	3.51	70
PP：RS = 10：1	15.45	8.21	64.03	40.11	45.59	3.55	68

[1] PP： peel of pineapple, RS： Rice straw, DM： dry matter, CP： crude protein, NDF： neutral detergent fiber, ADF： Acid detergent fiber, IVDMD： *in vitro* dry matter digestibility.

II. The silage of pineapple pills mixed with rice straw for feed dairy cows

In the study of the silage of pineapple pills mixed with rice straw for feed dairy cows, a total of 40 Holstein dairy cows were assigned into four groups for replicated feeding trials each last for 28-day. Four treated diets balanced for nutrition requirement included fresh pineapple pills mixed with rice straw at 0 (control), 3%, 6%, or 9% per day per cow. Results showed that cow performance fed with the four diets were all similar (Table 7). The averaged dry matter intake, milk yield, percentage of milk fat, milk protein, total solids, and milk urea nitrogen, cell counts were all close among groups, there were 18.1 kg, 23.3 kg, 3.80%, 3.41%, 12.73%, 12.4 mg/dL, respectively. Going through proper ensiling technique, the feeding values of pineapple pill and rice straw could be effectively promoted.

Table 7. Effect of supplementation of PPRS in diets on lactating performance of dairy cows

Item	Levels of PPR added into diets (DM basis)					Contrast Effect
	Control	3%	6%	9%	SEM	
Dry matter intake, kg/d	18.1	17.8	18.7	17.7	1.32	NS
Milk production, kg/d	22.5	23.8	23.2	23.5	0.97	NS
Feed efficiency(milk/intake)	1.25	1.34	1.24	1.33	0.08	NS
Milk fat, %	3.89	3.65	3.86	3.79	0.13	NS
Milk protein, %	3.44	3.38	3.48	3.34	0.08	NS
Milk lactose, %	4.73	4.76	4.72	4.86	0.05	NS
Milk solid not fat, %	8.89	8.83	8.89	8.91	0.10	NS

Milk total solid, %	12.95	12.53	12.96	12.48	0.20	NS
MUN, mg/dL [2]	12.5	11.9	12.8	12.4	0.43	NS

PPRS was mixed from pineapple pill and rice straw at 10：1 fresh weight ratio.All traits performances were similar among treatments (P > 0.05). Contrast effect： control vs. PPR.

On the economic benefits analysis, after reduced the feed fee, the crude income increased 6%, 2% and 5% for the 3%, 6% and 9% groups of pineapple pill mixed with rice straw added into diets, respectively (Table 8). On average, the crude income increased 4.3% which is equal to 20 NT$ head/day, that indicated the use of silage made by pineapple pills mixed with rice straw could increase the crude income overall.

Table 8. Evaluation of economic benefits of adding pineapple peel and rice straw silage to dairy cows

	Levels of PPRS added into diets (DM basis)			
Economic benefit	Control	3%	6%	9%
Feed price NT$/DM/kg	11.63	11.80	11.93	12.10
Feed cost NT$/head/day	211	211	223	214
Unit price of milk NT$/kg	28.99	28.61	28.99	28.80
Milk income NT$/head/day	652	681	673	677
Crude income NT$/head/day	441	470	450	463
Income over feed cost, %	100	106	102	105

III. Evaluation of silage of lemon pill pomaces mixed with napier grass for feed dairy cows

In this experiment lemon pill pomaces was used for material. The chemical contents of lemon pill pomaces were DM 18.57%, CP 7.02%, NDF 22.9%, ADF 18.82%, Ca 1.03% and P 0.17%. After ensiling, the pH of the silage made by lemon pill pomaces mixed with napier grass fresh weight at the ratio of 5：5 was 3.30 and the Flieg's score was 72. Beside it, the pH of the silage made by lemon pill pomaces mixed with napier grass fresh weight at the ratio of 3：7 was 3.20 and the Flieg's score was 96. Both silages had good quality. From the result showed those lactation performance of dairy cows was similar among the three groups. The average daily dry matter intake and milk yield was 21.9 kg/d and 22.57 kg/d, respectively. The averaged lactation efficiency (milk yield/DM intake) was 1.03 and was not different amongst treatments. As the cows were in the late lactation period, the lactation performance and lactation efficiency were low. The milk composition was not different between the silage made by lemon pill pomaces mixed with napier grass at ratio of 5：5 or 3：7. The percentage of milk fat, milk protein, milk lactose, non-fat milk solid and total solids were 3.89%, 3.38%, 4.87%, 9.13% and 13.2%, respectively indicated the milk quality was good. Previous research has found that the lemon fruit could be fed by fresh or by making silage for animal. The lemon, orange or grape fruit usually are dehydrated and added to the ration gradually to make the ruminants gradually accustom and accept the unquestionable flavor and taste (Bath et al., 1980). Whether the fruits were fed by fresh or silage form, it is usually quickly accepted by ruminants. The lemon pulp and peel are more acceptable than orange or grapefruit pulp and peel

(Bath *et al*., 1980). The fresh orange fruit is easy to be accepted for dairy cows, but it also have some problems such as transport, storage and treatment approach needed to be solved. The water content is high in fresh orange so it is often only transported in short distances because the long distance transportation cost is high (Lundquist, 1995). Due to the high sugar content in fresh orange to induce secondary fermentation and/or mold and attraction for flies, the fresh orange should be utilized quickly. Therefore ensiling might be adopted to solve the preservation problem (Grasser *et al*., 1995). Under fed with 100-150 g DM/day, fed with fresh citrus pulp did not increase the incidence of acidosis (Bampidis and Robinson, 2006). The evaluation of economic benefits of dietary lemon peel and napier grass mixed silage at 10% DM basis to dairy cows was shown in Table 10. Results showed that after deducted the feed fee, adding silage of lemon pill pomace mixed with napier grass at the ratio of 5：5 and 3：7 ratio decreased the crude income by 1.8% and 4.7%, respectively compared with the control group. But the crude income might be similar as there was no significant difference on milk production amongst the two silage groups and control group. The result also showed that the feeding efficiency of lemon pill pomace silage was similar to napier grass. Therefore the lemon pill pomace silage was suitable for feed resources of dairy cows (Table 9, 10).

Table 9. The Effects of adding lemon peel promace and Napier grass mixed for silage on lactation performance of dairy cows

Milk quality	Control	Lemon peel promace ： Napier grass 5：5 silage	Lemon peel promace ： Napier grass 3：7 silage	SEM
Dry matter intake, kg/d	22.5	21.9	21.3	-
Milk production, kg/d	23.1	22.7	21.9	2.04
Feed efficiency (milk/intake)	1.03	1.04	1.02	-
Milk fat, %	3.89	3.87	3.91	0.53
Milk protein, %	3.37	3.39	3.37	0.76
Milk lactose, %	4.85	4.89	4.87	0.73
Milk solid not fat, %	9.12	9.13	9.15	0.67
Milk total solid, %	13.1	13.1	13.4	0.71

All traits performances were similar among treatments ($P > 0.05$).

Table 10. Evaluation of economic benefits of lemon peel and napier grass mixed silage to dairy cows

Economic benefit	Control	Lemon peel promace ： Napier grass 5：5 silage	Lemon peel promace ： Napier grass 3：7 silage
Feed price NT$/DM/kg	12.46	12.61	12.60
Feed cost NT$/head/day	280	276	268
Unit price of milk NT$/kg	28.8	28.8	28.99
Milk income NT$/head/day	665	654	635
Crude income NT$/head/day	385	378	367

Income over feed cost, %	100	98.2	95.3

CONCLUSION

The price of feed and hay in the world has skyrocketed in recent years, causing the high production cost and concern of food security. Therefore, to explore available alternative feed resources becomes more and more important in Taiwan. From the studies above indicated that the ensiling technique could be one economical approach to preserve local agricultural and food processing by-products such as sweet potato, orange, grape fruit, kumqua and pineapple as feed resources for ruminants. Furthermore, improving the feed values of some fibrous but high quantity residues is also an effective way to expand feed resources. Using the ensiling technique of agricultural by-products and wastes is innovative recycling methods, those might be set up an agricultural recycling model and save feed cost.

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陸、照片附錄

此次參加「Agriculture Waste Management for Sustainable Food Production」國際研討會係由亞洲太平洋地區糧食肥料技術中心(FFTC)與馬來西亞農業發展研究所(Malaysian Agricultural Research and Development Institute, MARDI)以及菲律賓農業、漁業與資源研究發展委員會(Department of Science and Technology-Philippine council for Agriculture, Aquatic and Natural Resources and Development, DOST-PCAARRD)合辦之國際研討會，畜產試驗所參與此國際研討會，將研究成果和參與國研究人員交流，並了解亞太各國畜牧業在農業副產物資源技術現況及相關技術發展並尋求國際合作機會。此次國際研討會由 FFTC 張淑賢主任主持(圖 1)，計有馬來西亞、臺灣、韓國、日本、菲律賓、泰國、印尼、越南等 8 國（圖 2-8）參加共發表發表 12 篇有關農業副產物、廢棄物再利用及循環農業等相關論文，合計共 100 多位學者及專家參與，讓與會人員了解目前世界畜牧產業發展之近況與研究方向。本次會議後，亦由 FFTC 安排參訪業界參訪，包含金馬崙高原（Cameron Highlands)的 PJ Eco Recycling Plaza 參訪其零廢棄物技術應用之商店（圖 9-12），MARDI 有機農場的試驗內容及沼氣的試驗成果（圖 13-16）及 Chitose Oriental Lilyh 園區了解其如何將蔬果廚餘盡其使用（圖 17-20），達零廢棄物之作法進行經驗分享及技術交流。

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