Mj. Int. J. Sci. Tech., **2007**, *01*, 88-94

Maejo International

Journal of Science and Technology

ISSN 1905-7873

Available online at www.mijst.mju.ac.th

Full Paper

Agro-industrial by-products as roughage source for beef cattle: Chemical composition, nutrient digestibility and energy values of ensiled sweet corn cob and husk with different levels of Ipil – Ipil leaves.

Sompong Sruamsiri*, Pirote Silman and Warunee Srinuch

Department of Animal Technology, Faculty of Agricultural Production,

Maejo University, Sansai, Chiang Mai, 50290, Thailand

*Author to whom correspondence should be addressed, e-mail: sompong@mju.ac.th

Received: 7 March 2007; in revised form: 2 July 2007 / Accepted: 6 July 2007 / Published: 9July 2007

Abstract: This experiment was carried out to determine the nutritive value of agro-industrial by-products and nutrient digestibility of ensiled sweet corn cob and husk with different levels of Ipil - Ipil leaves (*Leucaena leucocephala*). Four native cattle were assigned by Latin Square Design to receive all dietary treatments in four experimental periods, i.e. ensiled sweet corn cob and husk (ESCH), ensiled sweet corn cob and husk + 10 % Ipil - Ipil leaves (ESCH + 10% IL), ensiled sweet corn cob and husk + 20% Ipil - Ipil leaves (ESCH + 20% IL) and ensiled sweet corn cob and husk + 30% Ipil - Ipil leaves (ESCH + 30% IL), respectively. Total collection method was used to determine the digestibility coefficients. Results showed that digestibility coefficients in ESCH were low ($P>0.05$) in all the nutrients. Supplementation of Ipil - Ipil leaves in ESCH increased digestibility coefficients. Total digestible nutrients (TDN) and digestible energy were higher in the silages supplemented with Ipil - Ipil leaves. Average TDN contents of ESCH, ESCH + 10% IL, 20% IL and 30% IL were 62.78 $\pm$ 6.14, 70.41 $\pm$ 4.04, 72.73 $\pm$ 2.78 and 63.07 $\pm$ 4.06 %DM, respectively.

Keywords: apparent digestibility, energy value, agro-industrial by-products, sweet corn cob and husk, silages, Ipil - Ipil leaves

---

Introduction

In dry season, the main problem of ruminant production in Thailand is nutrition, especially the quality and quantity of roughage which forced farmers to use other resources as feed. Crop residues especially rice straw are commonly used as main sources of roughage for cattle even though the nutritive value is low. When cattle are fed with rice straw or low quality roughage, supplemented feed containing protein or other energy source is required to improve both roughage utilization and growth performance.

At present, agro-industrial by-products from canning factory such as pineapple waste, passion fruit peel, baby corn waste and sweet corn cob and husk are commonly used as feed resources, especially as roughage. However, these by-products are high in moisture content and soluble carbohydrates, so it decay very quickly. Therefore, the ensiling of these by-products is suitable method of preservation even though the acidity of the cannary waste silage is usually high. Silage additives should be use for improving silage quality[1,2]. *Leucaena leucocephala* (Ipil Ipil) is the most popular legume species in cattle feeding. Because of their protein content is high, fresh or dried leaves are usually used as protein supplement. For preserving them ensiling process is also a good method [3]. In order to find out the appropriate methods of using agro-industrial by-products as new feed resources and how to preserve them throughout the dry season, analytical work to develop the database on chemical composition, nutritive value and nutrient digestibility was conducted. The objectives of this experiment were to determine the nutritive value of agro-industrial by-products which farmers usually use as roughage for cattle, as well as to determine the apparent digestibility and energy value of ensiled sweet corn cob and husk with different levels of Ipil - Ipil leaves.

Materials and Methods

1. Chemical composition

Agro-industrial by-products such as pineapple waste, passion fruit peel, baby corn waste and steamed cob and husk of sweet corn, which are by-products from canning factories in Chiang Mai were collected and sampled for analysis. To obtain a sufficient and uniform sample, each agro-industrial by-product was repeatedly sampled from several transport trucks and mixed thoroughly. Samples were then randomly taken for analysis of dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE), nitrogen free extract (NFE), calcium (Ca), phosphorus (P) and gross energy (GE) according to the methods described in AOAC [4]. The analysis of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were done according to Detergent method [5].

2. Digestibility study

For digestibility study, sweet corn cob and husk (SCH) collected from a canning factory was ensiled with different levels of Ipil - Ipil leaves and used as experimental diets. Ipil - Ipil leaves were prepared by chopping the whole branch whose diameter was not bigger than 1.5 cm before mixing. They were packed without additives in double layer polyethylene bags (25 x 30 inches) with vacuum suction. Each bag contained 20 kg. of silage and stored for 21 days prior to use. Four native beef cattle at two years of age with an average body weight 174 $\pm$ 13.5 kg. were randomly allocated to one of the four dietary treatments according to Latin Square Design. The treatments were (1) ensiled sweet corn cob and husk (ESCH), (2) ensiled sweet corn cob and husk and Ipil - Ipil leaves at 90:10 (ESCH + 10%IL), (3) ensiled sweet corn cob and husk and Ipil - Ipil leaves at 80:20 (ESCH + 20%IL) and (4) ensiled sweet corn cob and husk and Ipil - Ipil leaves at 70:30 (ESCH + 30%IL) (Figure 1). The silages were fed as single feed twice daily at least 1.5% of the body weight (DM

basis). Total collection method was assigned for the determination of apparent total tract digestibility of nutrients.

Each digestibility period lasted 21 days while preliminary period took place in the first 14 days and collection period was in the last 7 days. Silage intake was recorded daily through of the entire experiment. Silage DM intake was calculated on DM basis. Feces and leftover feed were collected and used for the calculation of nutrient digestibility. Total digestible nutrients (TDN) were calculated using the equation : TDN = digestible CP + digestible CF + digestible NFE + digestible EE × 2.25 [6]. Gross energy of feed and feces were determined using adiabatic bomb calorimeter (IKA calorimeter system C 5000). Digestibility was then calculated. The data were analyzed according to 4 × 4 Latin Square Design [7].

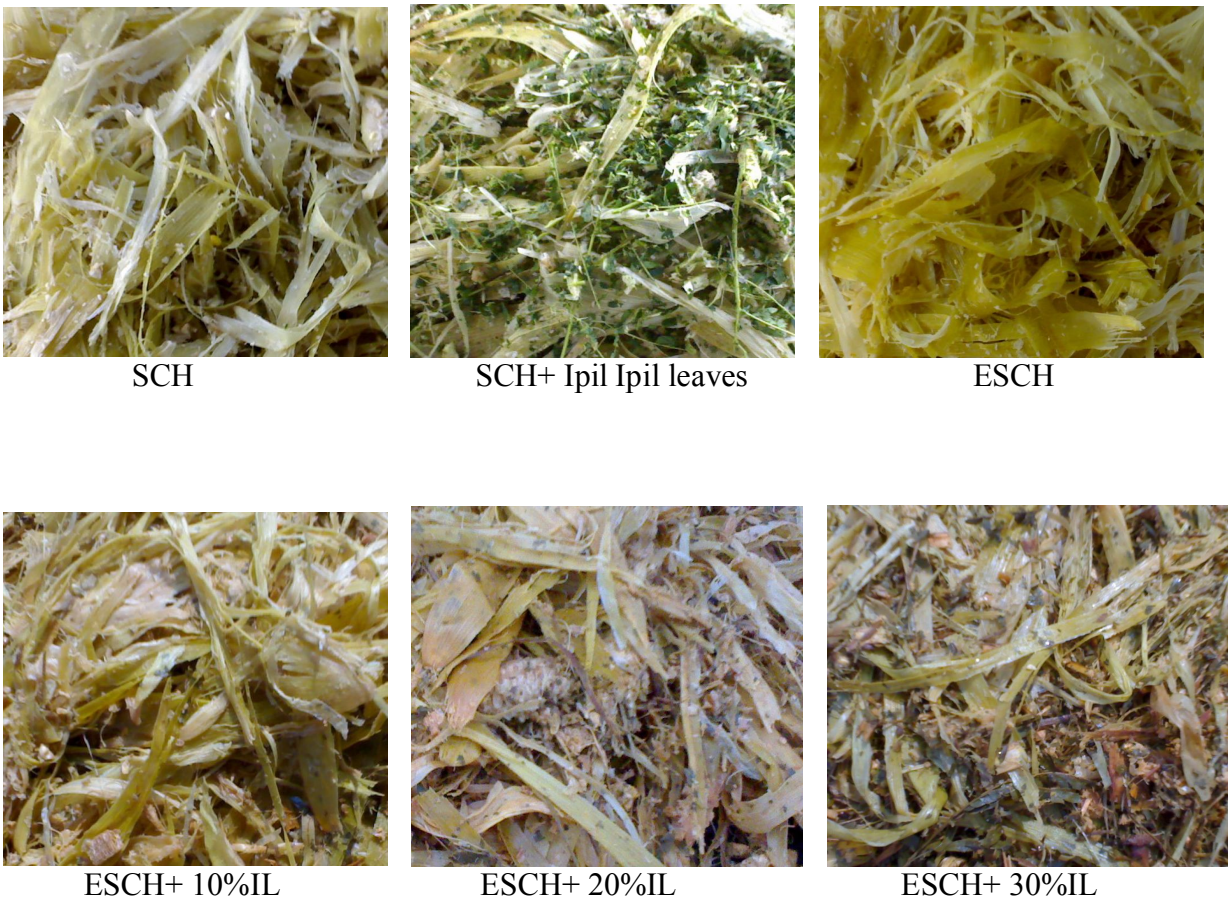

Figure 1. Sweet corn cob and husk (SCH), ensiled steamed sweet corn cob and husk (ESCH) with different levels of Ipil - Ipil leaves (IL).

Results and Discussion

Chemical composition of agro- industrial by-products

The dry matter contents of pineapple waste and pineapple silage (ensiled pineapple waste) were lower than those of baby corn husk, passion fruit peel, ensiled pineapple waste with rice straw and ensiled passion fruit. The average CP contents of agro-industrial by-products from the canning factories (Table 1) showed that all of these by-products were not the good roughage sources and should not be used as the main roughage for ruminants because of their low contents in CP and DM. However, baby corn husk was the highest in CP content (9.88% in DM) but the lowest in NDF and ADF contents (54.44 and 22.38% in DM), when compared to other by-products. The physical characteristic of ensiled pineapple wastes with or without rice straw were in good condition even though their DM content was lower than optimal range of good ensiling products. These might be due to the high NFE contents in pineapple waste especially fructose which are converted to lactic acid by lactic acid bacteria. Moreover, the supplement of rice straw increased DM content of the silage but decreased in CP content. The physical characteristic of rice straw was better after the ensiling process. It had lactic acid odor with light yellow color and the structure was softer.

Table 1. Chemical composition of agro-industrial by-products used in the experiment.

Items	DM (%)	% of DM		
		CP	NDF	ADF
Baby corn husk	19.35	9.88	54.44	22.38
Pineapple waste	9.12	7.32	78.98	31.45
Ensiled pineapple waste	8.11	7.42	70.43	34.58
Ensiled pineapple waste with rice straw (90:10)	17.23	5.76	76.51	44.56
Passion fruit peel	16.65	6.34	45.72	36.54
Ensiled passion fruit peel	18.76	7.06	44.68	32.25

The chemical compositions of SCH and ESCH without or with different levels of Ipil - Ipil leaves on DM basis were presented in Table 2. The data from the chemical compositions showed that SCH and ESCH could be used as roughage sources for ruminants even though their CP contents were lower than 8 % and the DM contents were lower than 20%. Furthermore, increasing Ipil - Ipil leaves in the silage tended to increase DM and CP contents, but the average percentages of organic matter (OM), CF, NDF and ADF tended to decrease with increasing Ipil - Ipil leaves in the silage. The positive effect of the silage with Ipil - Ipil leaves was due to the nutritive value of this legume, which was high in protein, DM and GE contents [8-9]. Although ESCH and ESCH + IL were good quality silages, ESCH+ 30% IL had high pH (4.32). The high pH of this treatment might be due to the buffering capacity of IL which is leguminous plant. Therefore, the recommended Ipil – Ipil levels ensiling with ESCH is at 10 – 20 %.

Table 2. Chemical composition of sweet corn cob and husk (SCH), ensiled sweet corn cob and husk (ESCH) with out or with Ipil Ipil leaves (IL).

Item	DM (%)	% of DM									GE (kcal/gDM)	pH
		OM	CP	CF	EE	NFE	NDF	ADF	Ca	P		
SCH	19.32	96.56	8.69	23.26	5.24	59.37	75.62	34.04	0.43	0.20	4.41	-
Ipil – Ipil leaves	33.76	91.62	18.15	18.47	4.21	50.79	63.47	28.60	0.73	0.31	4.17	-
ESCH	18.73	96.54	9.13	22.86	5.34	59.21	74.27	31.94	0.61	0.23	4.33	3.92
ESCH + 10% IL	18.89	96.38	12.29	20.22	5.68	58.19	72.92	30.80	0.63	0.30	4.65	4.04
ESCH + 20% IL	19.47	95.52	13.57	20.74	5.32	55.89	69.47	30.62	0.64	0.28	4.85	4.15
ESCH + 30% IL	20.69	95.18	14.08	21.65	5.47	53.98	68.42	30.28	0.56	0.26	4.76	4.32

Apparent digestibility of nutrients

Table 3 shows the digestibility of ESCH with or without Ipil - Ipil leaves. It was shown that cattle fed ESCH + IL consumed slightly higher dry matter content than the ESCH-fed group (2.69, 2.89, 3.01 and 3.05 kg/h/d which are equal to 1.58, 1.64, 1.72 and 1.74% BW, respectively). This might be due to the supplement of Ipil – Ipil leaves in the silages, which provided more nutrients, especially nitrogen for microbial growth and activities. The result from this experiment agreed with that of Oldham [10], who found that dry matter intake and nutrient digestibility of the diet increased with increasing crude protein contents. Therefore, the digestibility of nutrients in cattle fed with ESCH + IL were higher than the ESCH group. The apparent digestibility of DM, OM and CP were significantly different among treatments ($P<0.05$). ESCH had lower DMD, OMD and CPD than other treatments. No significant differences among groups were found on the apparent digestibility of CF, EE and ADF ($P>0.05$).

Table 3. Apparent digestibility of ensiled sweet corn cob and husk (ESCH) with or without Ipil - Ipil leaves (IL) in 4 native beef cattle.

Apparent digestibility, %	ECSH	ESCH+ 10% IL	ESCH+ 20% IL	ESCH+ 30% IL
DM*	52.77 ^{c} ± 6.12	66.24 ^{ab} ± 5.33	70.32^{a} ± 3.24	60.28 ^{b} ± 4.11
OM*	56.90 ^{c} ± 5.68	68.09^{a} ± 4.21	73.34 ^{a} ± 4.53	63.68 ^{ab} ± 5.37
CP*	49.27 ^{c} ± 5.22	56.08 ^{b} ± 5.13	68.59 ^{a} ± 1.88	55.49 ^{b} ± 3.26
CF	62.41 ± 5.08	64.50 ± 3.17	61.42 ± 1.02	57.44 ± 3.86
EE	75.68 ± 2.45	81.43 ± 3.01	82.40 ± 2.32	76.82 ± 1.87
NFE*	53.96 ^{b} ± 4.13	69.05 ^{a} ± 3.76	73.52 ^{a} ±3.17	67.57 ^{a} ± 3.34
NDF*	59.34 ^{b} ± 4.11	63.34 ^{b} ± 2.68	72.27 ^{a} ± 1.91	62.54 ^{b} ± 4.16
ADF	46.53 ± 4.28	52.00 ± 4.02	53.93 ± 3.24	49.73 ± 1.85

* Mean with different superscripts differ significantly ($P<0.05$)

The apparent digestibility of NFE and NDF followed the same pattern as DM digestibility and was significantly different ($P<0.05$) as influenced by supplementation with Ipil - Ipil leaves.

Calculation of TDN from digestibility of nutrients showed that ESCH had a high average value of TDN and they can be used as roughage source for ruminants. Digestible energy contents of the silages followed the same pattern as TDN contents (Table 4).

Table 4. Total digestible nutrients (TDN) and digestible energy of ensiled steamed cob and husk of sweet corn (ESCH) with or without Ipil - Ipil leaves (IL) in 4 native beef cattle.

Item	DM (%)	DM basis	
		TDN (%)	DE (Mcal / kg)
ESCH	18.73	62.78 $\pm$ 6.14	2.54 $\pm$ 0.23
ESCH + 10% IL	18.89	70.41 $\pm$ 4.04	2.96 $\pm$ 0.07
ESCH + 20% IL	19.47	72.73 $\pm$ 2.78	3.11 $\pm$ 0.04
ESCH + 30% IL	20.69	63.07 $\pm$ 4.06	2.68 $\pm$ 0.12

Conclusion

The chemical composition of all the wastes from canning factories, e.g. pineapple waste, passion fruit peel, are low in CP and DM contents. Sweet corn cob and husk is one of the agro-industrial by-products from the canning factory which can be preserved as silage and used as roughage for ruminants. The supplement of ensiling material with Ipil - Ipil leaves increases CP, TDN and DE contents as well as the digestibility of nutrients, compared to the unsupplemented sweet corn cob and husk silage.

Acknowledgements

This study was supported by a grant from "Establishment of Feeding Standard of Beef Cattle and Feedstuff Database for Indochinese peninsula research fund" of Japan International Research Centre for Agricultural Sciences.

References

1. C. Kayouli, "A Strategy for Animal Nutrition in the Dry Sub-tropic.", In *Intl.* Symp. *on the Constraints and Possibilities of Ruminant Production in the Sub-Tropics,* Proc. of the Ministry of Agriculture, Egypt/ESAP/EAAP/FAO/ICAMS/WAAP, Cairo, Egypt, November. **1988**, p 201-206.
2. A. F. Mutafa, F. Hassanat, and R. R. Berthiaume, "Situ Forestomach and Intestianl Nutrient Digestibilities of Sweet Corn Residues", *Animal Feed Sci. Tech.*, **2004**, *114*, 287-293.
3. G .Jaurena and G. Pichard, "Contribution of Storage and Structural Polysaccharide to the Fermentation Process and Nutritive Value of *Leucaena leucocephala* Ensiled Alone or Mixed with Cereal Grain", *Animal Feed Sci. Tech.*, **2001**, *92*, 159-173.
4. AOAC, "Official Method of Analysis", 16th ed. Association of Official Analysis Chemists, Gaithergurg, **1998.**
5. P. J. Van Soest, J. B. Robertson, and B. A. Lewis, "Methods of Dietary Fiber, Neutral Detergent Fiber and Nonstarch Polysaccharides in Relation to Animal Nutrition", *J. Dairy Sci.*, **1991**, *74*, 3583-3597.
6. W. G. Pond, D. C. Church, and K. R. Pond, "Basic Animal Nutrition and Feeding", 4 th ed. John Wiley & Sons. New York, **1995**.
7. R. G. D. Steel and J. H. Torrie, "Principles and Procedures of Statistics", 2nd Ed. McGraw-Hill., New York, **1980**.
8. H. M. Shelton and J. L. Brewbaker, "*Leucaena leucocephala* - the Most Widely Used Forage Tree Legume", in "Forage Tree Legumes in Tropical Agriculture", (Ed., R. C. Gutteridge and H. M. Shelton), *CAB International*, Wallingford, **1994**, pp. 15-29.
9. B. W. Norton, "The Nutritive Values of Free Legumen", in "Forage Tree Legumen in Tropical Agriculture", (Ed., R. C. Gutteridge and H. M. Shelton), *CAB International*, Wallingford, **1994**, pp. 177-194.
10. J. D. Oldham, "Protein-Energy Interrelationships in Dairy Cows", *J. Dairy Sci.*, **1984**, 67, 1090.