

Effects of Steam and Alkali Treatment on Chemical Composition and *in vitro* Digestibility of Oil Palm Trunks

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Abstrak

Dalam kajian pencernaan oleh lembu batangkelapa sawit (BKS) dibelah ke bentuk papan, dihancurkan ke bentuk kepingan-kepingan halus dan diproses. Saiz optimum kepingan ialah 2 cm dan tiga rawatan telah diberi iaitu pengeringan, pengstimulan dan perawatan dengan alkali. Analisis kimia dan penghadaman *in vitro* ditentukan ke atas BKS tadi. Rawatan pengstimulan mengurangkan kandungan neutral detergent fiber (NDF) tetapi tiada memberi kesan kepada kandungan asid detergent fiber (ADF). Kandungan asid detergent lignin (ADL) juga berkurangan. Nilai optimum penghadaman bahan kering BKS pada tekanan wap 7.5, 10.0, 12.5 dan 15.0 kg/cm diperoleh pada masa pengstimulan 60, 20, 10 dan 5 minit. Rawatan dengan sodium hidroksida mengurangkan NDF. Kandungan ADF mula berkurangan hanya pada kepekatan NaOH melebihi daripada 6%. Kandungan ADL meningkat disebabkan oleh pemecahan ikatan lignin-polisakarid dan seterusnya meningkatkan penghadaman *in vitro* bahan kering BKS. Penghadaman optimum telah diperoleh pada rawatan dengan 9% NaOH selama 14 hari.

ABSTRACT

Oil palm trunks (OPT) were sawn into planks, reduced to flakes, and processed for use in feeding trials to bulls. The optimum size of flakes was found to be 2 cm with three different treatments for drying, steaming and alkali treatments. Chemical analysis and *in vitro* dry matter digestibility were determined on the materials. Steam treatment decreased the neutral detergent fiber (NDF) content but did not cause considerable change in the acid detergent fiber (ADF) content. The acid detergent lignin (ADL) content was increased. The optimum dry matter digestibilities at steam pressures of 7.5, 10.0, 12.5 and 15.0 kg/cm were obtained at steaming times of 60, 20, 10 and 5 min, respectively. Treatment with sodium hydroxide also decreased the NDF content. The ADF content was only lowered at concentrations of NaOH greater than 6%. The ADL content was increased due to removal of carbohydrates. Disruption of the lignin-polysaccharide bonds led to a rise in the *in vitro* dry matter digestibility (IVDMD). The optimum digestibility was obtained by treatment with 9% NaOH for 14 days.

Introduction

The large quantity oil palm trunks (OPT) and fronds generated in the country has little economic value at present and gives rise to a large problem of disposal. It is therefore imperative that efforts be made to exploit this rich lignocellulosic resource. One of the most promising ways to promote the utilization of oil palm trunks is in the production of animal feed.

Though the OPT contains enough cellulose to make it an excellent source of energy for ruminants, it is a poor quality feed in its natural state (Abe *et al.* 1988). It cannot be used as the only source of nutrients for ruminants and must be processed or supplemented by other ingredients. The main shortcomings of OPT as animal feed are low protein content, high lignin content and low digestibility.

Several hardwoods such as aspen, poplar (Mathews and Pepper 1978) and white birch (Takigawa 1987) have been reported to show some potential as ruminant feed if processed by steaming. Alkali treatment with caustic soda, ammonia, calcium hydroxide, urea or ash (Jackson 1977; Kategile and Frederiksen 1979) has also been used as one of the most common methods to improve the digestibility of low quality fibrous materials such as rice straw, barley straw or bagasse. The oil palm trunk has tissue structure and composition somewhat different from normal wood or other cereal residues (Killmann and Lim 1985). It should therefore respond in a somewhat different manner when processed by steaming or alkali for ruminant feed. The effect of such treatments on the digestibility of flakes from oil palm trunks forms the basis of the present investigation.

MATERIAL AND METHODS

Materials

Oil palm trunks, 33 years old, were harvested from the Minyak Estate, Batang Berjuntai, Selangor. The trees were push-felled by an excavator and sawn into 2m billets, starting at 2m from the base. The billets were transported back to FRIM where they were sawn into planks by a gangsaw and bandsaw. The size of the planks were 4 x 30 x 200 cm. Flakes less than 2 cm length were then prepared from the planks using a Pallmann drum flaker.

Methods

1. Treatments

The oil palm flakes were subjected to 3 kinds of preliminary treatment:

- (i) Drying: A portion of the flakes was partially dried in the sun for 3-4 days. The drying was completed in an oven at 60° - 65° C.
- (ii) Steaming: Fifteen steaming conditions, as shown below were set up to determine the best steaming condition for OPT.

Steam pressure (kg/cm)	Steaming time (min)
7.5	10, 30, 60
10.0	1, 5, 10, 20, 30
12.5	1, 5, 10, 20
15.0	1, 5, 10

The steam digester (HZ-FB-100 manufactured by Hitachi) was used in these experiments. The moisture content of OPT was adjusted to 25% before steaming.

- (iii) NaOH treatment: OPT was treated with five different levels (0, 3, 6, and 12% of dry matter, DM) of NaOH. Dried OPT was mixed with each NaOH solution and water was added until a moisture content of about 50% was attained. The well mixed treated OPT was stored in sealed containers at room temperature for 1, 3, 7, 14, 21 and 28 days.

2. Analysis

The methods described by the Association of Official Analytical Chemists (Anon. 1970) were used to determine total ash and crude protein (CP). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analysed by the methods of Goering & Van Soest (1970). *In vitro* dry matter digestibility (IVDMD) was conducted by the method as reported by Goto and Minson (1977).

RESULTS AND DISCUSSION

The maximum suitable size of the oil palm flakes was fixed at 2 cm since earlier observations by Oshio (1989) indicated that flakes beyond this size caused chewing difficulties and were not easily accepted by the bulls.

Determination of the Best Condition for Steam Treatment

The results of steam treatment on the chemical composition of OPT are presented in Table 1. The pH and neutral detergent (NDF) content were lowered by steaming. It was presumed that hemicellulose was decomposed to soluble carbohydrates (i.e. glucose and xylose) and organic acids (i.e. acetic acid and lactic acid) as reported by Oshio *et al.* (1989). Acid detergent

TABLE 1
Nutrient composition of steam-treated oil palm trunk
(% of dry matter, DM)

Treatment		DM.	pH	% of DM.				
Pressure	Time			Total ash	CP	NDF	ADF	ADL
kg/cm	(minute)							
Control	-	92.6	3.7	2.5	1.8	93.1	54.0	9.3
7.5	10	90.3	3.3	3.1	1.7	76.7	53.5	9.9
	30	90.7	2.9	3.4	1.8	64.3	51.3	11.6
	60	88.9	2.9	3.2	2.0	61.3	51.0	13.0
10.0	1	89.3	3.3	3.0	1.7	80.7	57.1	9.5
	5	90.7	3.2	2.9	1.7	72.1	54.5	11.7
	10	86.1	2.9	3.2	2.0	62.3	51.7	14.6
	20	88.4	2.9	3.0	1.9	64.9	54.6	11.2
	30	78.7	2.8	3.5	2.0	58.6	52.8	15.4
12.5	1	91.2	3.2	3.1	1.7	72.6	52.7	10.2
	5	87.0	3.0	3.4	1.9	61.4	49.7	8.2
	10	82.4	3.0	3.1	1.9	59.4	51.9	10.2
	20	81.0	2.7	3.6	2.0	60.0	57.4	12.8
15.0	1	89.8	2.9	2.9	1.8	63.6	50.0	9.1
	5	84.3	2.6	3.2	2.0	58.0	51.8	8.7
	10	79.6	2.4	3.5	2.2	63.3	55.2	15.2

a = crude protein
b = neutral detergent fibre

c = acid detergent fibre
d = acid detergent lignin

fiber (ADF) content showed no marked change. Acid detergent lignin (ADL) and total ash contents increased with the increase in steaming time at each pressure level. This was due to the loss of hemicellulose and other easily hydrolyzed materials during the steaming process. The dry matter loss was 1.5% to 15.0% as shown in Table 1. Oshio *et al.* (1990) determined that the higher the pressure and the longer the steaming time, the lower was the recovery rate in dry matter. Table 2 and Figure 1 show the increase in *in vitro* dry matter digestibility (IVDMD) at different steaming time based on steam treated OPT flakes. The maximum values of DMD at the pressures of 7.5, 10.0, 12.5 and 15.0 kg/cm were obtained at steaming times of 60, 30, 20 and 5 minutes respectively. These IVDMD values were equivalent to or better than those of most tropical grasses (Goto and Minson, 1977; Pace *et al.*, 1984). By steaming, acetyl groups in xylan or glucomannan are converted to acetic acid, producing a low pH in the vapour which causes hydrolysis or

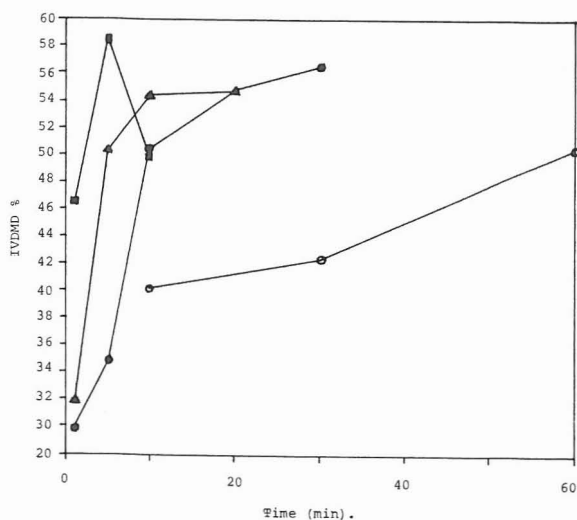


Fig. 1: Increase in IVDMD at different steaming time based on steam-treated oil palm trunks.

○—○ 7.5 kg/cm² ●—● 10.0 kg/cm²
▲—▲ 12.5 kg/cm² ■—■ 15.0 kg/cm²

TABLE 2
Effect of steam treatment on the *in vitro* dry matter digestibility (IVDMD)

Pressure (kg/cm)	Time (min)	IVDMD %
7.5	10	40.1
	30	42.4
	60	50.5
10.0	1	29.8
	5	34.8
	10	50.5
	20	54.8
	30	56.6
12.5	1	31.8
	5	50.4
	10	54.4
	20	54.7
15.0	1	46.5
	5	58.5
	10	49.8

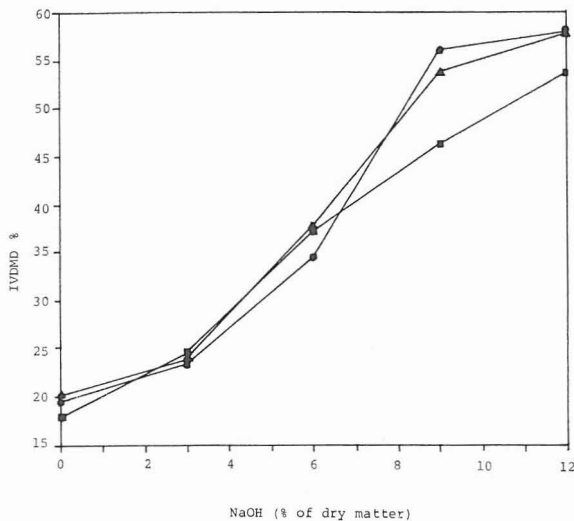


Fig. 2: Increase in IVDMD at different of concentration based on NaOH-treated oil palm trunks.

■ — 1 day ● — 28 days
Δ — 14 days

breakdown of the large molecules of lignin and hemicellulose. As a result, the cellulose which was previously coated with lignin is exposed to the

cellulolytic enzymes by the breakdown of the lignin and is hydrolyzed (Oshio *et al.* 1989).

Determination of the Best Condition for NaOH Treatment

The results of NaOH treatment on the chemical composition of OPT are presented in Table 3. The pH and total ash were increased by increasing the NaOH concentration. These values were not influenced by the storage time. The crude protein (CP) and NDF contents were slightly decreased by storage time. NaOH concentration significantly influenced NDF and CP contents. NDF content started to show a decline after increasing NaOH concentration greater than 3%. CP value started to decrease at 3% of NaOH concentration. NDF and CP decreased due to reduction in hemicellulose, lignin and soluble protein contents.

A marked drop in ADF was observed at 9%. Duration of treatment did not greatly influence the ADF content. The lowest ADF values were obtained at 12% NaOH at each storage time. OPT treated with NaOH for 28 days had higher ADL values compared to that treated for 1 day especially at lower NaOH concentration. ADL content increased due to the loss of soluble materials during the NDF and ADF analyses as shown in Table 3. This loss was caused by the disruption of the lignocellulosic bonds with NaOH treatment. Disruption of the lignocellulosic bonds also increased the IVDMD (Oshio *et al.* 1989).

The untreated samples at the end of the storage time had very similar IVDMD (18 - 20%, Table 4). However, after treatment with NaOH, the digestibility of OPT increased nearly linearly from 3% to 9% of NaOH as shown in Table 4 and Figure 2. At 12% of NaOH, almost similar values of the IVDMD were obtained for 14 days and 28 days of storage time. The optimum concentration and storage time were 9% NaOH and 14 days. The IVDMD values increased slowly after this concentration. Thus, although 12% NaOH gave higher IVDMD values, the increases do not justify the higher concentration of alkali needed. The IVDMD values of this optimum condition, moreover, was equivalent to or better than most tropical grasses (Goto and Minson 1977; Pace *et al.* 1984).

TABLE 3
Nutrient composition of NaOH-treated oil
palm trunks (% of dry matter, DM)

Day	Treatment		% of DM.				
	NaOH, %	pH	total ash	CP	NDF	ADF	ADL
1	0	4.6	2.5	2.4	93.1	54.0	10.5
	3	9.2	6.3	2.2	90.6	54.3	11.1
	6	13.8	8.2	2.0	82.8	50.9	18.4
	9	14	10.4	1.8	75.9	42.7	20.4
	12	14	12.7	1.9	80.9	44.6	23.3
14	0	4.1	2.5	2.6	91.9	61.2	16.5
	3	8.4	6.6	1.9	94.8	61.1	16.8
	6	10.9	8.5	1.8	77.0	57.3	23.3
	9	14	11.2	1.8	65.8	46.6	25.6
	12	14	12.4	1.6	62.3	41.8	18.6
28	0	3.6	2.7	2.2	80.3	64.7	20.3
	3	10.6	5.9	1.9	84.1	63.7	21.2
	6	12.0	8.4	1.9	71.9	53.5	21.5
	9	14	12.2	1.6	59.3	43.9	24.6
	12	14	14.0	1.7	62.9	42.7	23.7

a = crude protein
b = neutral detergent fibre

c = acid detergent fibre
d = acid detergent lignin

TABLE 4
Effect of NaOH treatment on the *in vitro*
dry matter digestibility (IVDMD)

Storage (day)	NaOH (% of dry matter)	IVDMD %
1	0	17.9
	3	24.5
	6	37.2
	9	46.2
	12	53.8
14	0	20.1
	3	23.9
	6	37.7
	9	53.8
	12	57.8
28	0	19.5
	3	23.3
	6	34.4
	9	56.0
	12	58.1

Improvement of the digestibility with NaOH treatment is probably due mainly to the cleavage of ester-linked lignin-polysaccharides complexes and the concomitant solubilization of the lignin (Chesson 1988). As a result, cellulose is exposed to cellulolytic enzymes by the breakdown and removal of the lignin and is digested.

CONCLUSION

The oil palm trunk appears to be a very promising fodder source for ruminants if properly processed by physical and chemical means. The maximum dry matter digestibilities at steam pressures of 7.5, 10.0, 12.5 and 15.0 kg/cm were obtained at steaming times of 60 min (50.5%), 30 min (56.6%), 20 min (54.7%) and 5 min (58.5%), respectively. The best condition of NaOH treatment was obtained at 9% NaOH for 14 days (53.8%).

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