Evaluation of the Feeding Value of Palm Press Fibre Using
In Vitro Digestibility Techniques

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ABSTRACT

Palm press fibre (PPF) was obtained from two sources, a small-scale oil palm processing unit and a
large-scale factory processing unit, and its chemical composition was determined. In vitro digestibility
techniques were used to assess the feeding value of untreated, defatted and sodium hydroxide-treated
PPF. For the NaOH treatment, 0.5 g oven-dried PPF was treated for 24 h with 5% NaOH in three ways:
treated and not washed (NaNW); treated and washed (NaW); and treated after milling (NAD).

The results indicate that, on a dry matter basis, PPF is low in nitrogen (12–13 g/kg), moisture (37–90 g/kg) and ash (53–62 g/kg), but high in ether extract (269–355 g/kg), neutral detergent fibre (532–768 g/kg), acid detergent fibre (375–548 g/kg) and lignin (219 g/kg). The in vitro dry matter digestibility
values were low for the samples from both sources, but the large-scale factory-processed PPF had higher in vitro dry matter digestibility (0.215 vs 0.166) and in vitro organic matter digestibility (0.196 vs
0.145). Defatting the PPF and treating it with 5% NaOH solution significantly (p < 0.01) improved both
the dry matter and organic matter digestibility. Washing the NaOH-treated PPF resulted in a higher
digestibility of dry matter as against NaNW or NAD. These results suggest that defatting and treatment
with 5% NaOH would improve the feeding value of PPF.

Keywords: alkali, by-product, composition, defatting, digestibility, feedstuff, oil palm, ruminant

Abbreviations: IVDMD, in vitro dry matter digestibility; IVOMD, in vitro organic matter digestibility;
NAD, PPF treated with 5% NaOH; NaNW, PPF treated with 5% NaOH; NaW, PPF treated with 5% NaOH and washed; PPF, palm press fibre; UTRD, untreated PPF

INTRODUCTION

Poor development of grassland resources, coupled with the scarcity of quality feed-
stuffs, particularly during the dry season, poses a major constraint to the development
of animal production in many countries in sub-Saharan Africa. Therefore, the
exploitation of other feed sources, such as crop residues and agroindustrial by-
products, for which humans and animals do not compete directly, is highly desirable.

Palm press fibre (PPF) is an agroindustrial by-product obtained after the extraction
of palm oil from oil palm fruit. A small proportion is used as fuel but most is discarded
as waste. Extraction of palm oil from palm fruits in Ghana is carried out by either
small-scale or large-scale factory processing units, whose different efficiencies are likely to
affect the nutritive value of PPF. The cheap and ready availability of PPF makes it an
attractive material for studying of the prospect of substituting it for other relatively scarce energy sources for ruminant feed, even though earlier studies have shown it to have high lignin content (213 g/kg DM) and low degradability, below 0.400 (Jelan et al., 1986). A study was therefore undertaken to determine the nutrient composition of PPF from both small-scale and large-scale factory processing units, to evaluate its feeding value using in vitro techniques and to assess the improvement in the digestibility of PPF after treatment with 5% NaOH solution.

MATERIALS AND METHODS

Chemical analysis

Representative samples of wet PPF obtained from a small-scale factory processing unit in Kumasi and oven-dried at 40–60°C for 48 h, and of fairly dry PPF that had been sun-dried for 48 h, obtained from a large-scale factory processing unit, also in Kumasi, were chemically analysed. The samples were analysed for dry matter (DM), ether extract (EE) and ash (AOAC, 1990). Nitrogen was determined using the Kjeldahl procedure (AOAC, 1990). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were estimated by the method of Goering and Van Soest (1970). Hemicellulose was calculated by difference.

In vitro dry matter digestibility and in vitro organic matter digestibility of untreated and defatted PPF

Dried samples of untreated PPF obtained from the two different processing units were ground through a 1-mm screen. Quadruplicate samples, each weighing 0.5 g, were taken and placed into 80 ml plastic centrifuge tubes and inoculated with rumen liquor obtained from a fistulated steer. Other samples of 4.5 g PPF obtained from the two sources were defatted by boiling with petroleum ether (BP 60–80°C) under reflux for 16 h. Samples of 0.5 g of the defatted PPF were then weighed into plastic centrifuge tubes in quadruplicate and also inoculated with rumen liquor. The in vitro dry matter and organic matter digestibilities of all the samples were then determined using the two-stage technique of Tilley and Terry (1963).

Treatment with 5% NaOH and in vitro dry matter and organic matter digestibility of the untreated PPF

Dry samples of 10 g of PPF from both the small- and large-scale factory processing units were treated with 200 ml (w/v) 5% NaOH for 24 h. The NaOH solution was then drained off and the PPF was thoroughly washed with four changes of 500 ml each of cold water to remove any NaOH present. This material was designated NaW. Another 10 g sample of dry PPF from each source was similarly treated with 200 ml 5% NaOH
solution, but the treated samples were not washed. This was designated NaNW. All the treated samples of PPF from both oil mills were oven-dried for 48 h at 40-60°C and then milled through a 1-mm screen. Samples of 0.5 g, oven-dried weight, were taken for in vitro dry and organic matter digestibility analyses, as for the untreated PPF (Tilley and Terry, 1963). Finally, previously milled but otherwise untreated PPF samples (0.5 g) from each of the two mills were treated with 10 ml of 5% NaOH solution for 24 h. This type of sample was designated as NAD and its in vitro dry matter (IVDMD) and organic matter (IVOMD) digestibility were immediately estimated. The IVDMD and IVOMD of each treated PPF was compared to that of untreated PPF (UTRD).

Statistical analysis

The data were analysed by analysis of variance (Steel and Torrie, 1980) and comparisons among the means were made from the least significant difference (LSD).

RESULTS

The nutrient compositions of the PPF from the two oil mills are shown in Table I.

TABLE I
Chemical composition of palm press fibre (g/kg dry matter)

<table>
<thead>
<tr>
<th>Component</th>
<th>Small-scale factory sample of product</th>
<th>Large-scale factory sample of product</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>963</td>
<td>910</td>
<td>20</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>12</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Ether extract</td>
<td>355</td>
<td>269</td>
<td>43</td>
</tr>
<tr>
<td>Neutral detergent fibre</td>
<td>532</td>
<td>768</td>
<td>87</td>
</tr>
<tr>
<td>Acid detergent fibre</td>
<td>375</td>
<td>548</td>
<td>86</td>
</tr>
<tr>
<td>Hemicellulose</td>
<td>157</td>
<td>220</td>
<td>31</td>
</tr>
<tr>
<td>Acid detergent lignin</td>
<td>134</td>
<td>219</td>
<td>41</td>
</tr>
<tr>
<td>Ash</td>
<td>62</td>
<td>53</td>
<td>4</td>
</tr>
</tbody>
</table>

SE, standard error of mean
TABLE II
In vitro dry matter digestibility (IVDMD) and in vitro organic matter digestibility (IVOMD) of palm press fibre (PPF) from large-scale and small-scale factory processing units

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Small-scale factory</th>
<th>Large-scale factory</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVDMD</td>
<td>0.166\textsuperscript{a}</td>
<td>0.215\textsuperscript{b}</td>
<td>0.024</td>
</tr>
<tr>
<td>IVOMD</td>
<td>0.145\textsuperscript{a}</td>
<td>0.196\textsuperscript{b}</td>
<td>0.026</td>
</tr>
</tbody>
</table>

Means in the same row with different superscripts are significantly different (p < 0.01)

SE, standard error of mean

TABLE III
In vitro dry matter digestibility (IVDMD) and in vitro organic matter digestibility (IVOMD) of undefatted and defatted palm press fibre from large-scale and small-scale factory processing units

<table>
<thead>
<tr>
<th>Source</th>
<th>Parameter</th>
<th>Undefatted</th>
<th>Defatted</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small-scale factory</td>
<td>IVDMD</td>
<td>0.166\textsuperscript{a}</td>
<td>0.345\textsuperscript{b}</td>
<td>0.089</td>
</tr>
<tr>
<td></td>
<td>IVOMD</td>
<td>0.145\textsuperscript{a}</td>
<td>0.322\textsuperscript{b}</td>
<td>0.088</td>
</tr>
<tr>
<td>Large-scale factory</td>
<td>IVDMD</td>
<td>0.215\textsuperscript{a}</td>
<td>0.284\textsuperscript{b}</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>IVOMD</td>
<td>0.196\textsuperscript{a}</td>
<td>0.264\textsuperscript{b}</td>
<td>0.034</td>
</tr>
</tbody>
</table>

Means in the same row with different superscripts are significantly different (p < 0.01)

SE, standard error of mean

The IVDMD and the IVOMD of untreated palm press fibre from the two mills are shown in Table II. Both IVDMD and IVOMD of PPF from the large-scale factory processing unit were higher than those of PPF from the small-scale factory processing unit.

Defatting the PPF significantly (p < 0.01) improved the IVDMD and IVOMD from both sources (Table III). The improvement was greater for the PPF from the small-scale factory than for the large-scale factory, for both IVDMD and IVOMD.
### TABLE IV
The effect of treatment with NaOH on the digestibility of palm press fibre from large-scale and small-scale factory processing units

<table>
<thead>
<tr>
<th>Source</th>
<th>Parameter</th>
<th>UTRD</th>
<th>NaNW</th>
<th>NaW</th>
<th>NAD</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small-scale factory</td>
<td>IVDMD</td>
<td>0.166&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.217&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.375&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.203&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.046</td>
</tr>
<tr>
<td></td>
<td>IVOMD</td>
<td>0.145&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.1979&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.351&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.182&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.043</td>
</tr>
<tr>
<td>Large-scale factory</td>
<td>IVDMD</td>
<td>0.215&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.243&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.312&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.229&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.022</td>
</tr>
<tr>
<td></td>
<td>IVOMD</td>
<td>0.196&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.221&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.292&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.208&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.021</td>
</tr>
</tbody>
</table>

Means in the same row with different superscripts are significantly different (p < 0.01)
SE, standard error of mean

UTRD, untreated; NaNW, treated with 5% NaOH, not washed before being milled; NaW, treated with 5% NaOH and washed before being milled; NAD, milled and then treated with 5% NaOH, not washed

NaOH treatment of the PPF from the two processing units (Table IV) resulted in significant differences (p < 0.01) in both the dry matter and organic matter digestibilities. Significant differences (p < 0.01) were also observed in the effects of the various methods of treatment. Treatment of PPF from either source with 5% NaOH solution for 24 h followed by washing with cold water (NaW) gave the greatest improvement in both IVDMD and IVOMD, while direct treatment of milled PPF (NAD) gave the least improvement. In general, the improvement in IVDMD and IVOMD of PPF treated with 5% NaOH solution was greater for PPF from the small-scale factory than for that from the large-scale factory.

### DISCUSSION

The different methods of drying may account for the differences in the dry matter percentage of the PPF from the small-scale and large-scale factory processing units. The nitrogen values obtained in this study (Table I) were similar to those reported by Hutagalung (1981) and Wan Mohammed and colleagues (1987). The greater ether extract value for PPF from the small-scale processing unit (355 g/kg) compared to that from the large-scale unit (269 g/kg) was probably due to differences in the efficiency of extraction. The manually operated screw press extraction method used at the small-scale factory appears to be less efficient than the hydraulic press processes employed by the large-scale factory. The ether extract values obtained in this study were higher than those reported by Hutagalung (1981) (210 g/kg) and Wan Mohammed and colleagues (1987) (140 g/kg). Again, these differences may be attributable to different oil extraction techniques being employed.
The use of different varieties of oil palm fruits might account for the differences observed for the PPF from the two sources with respect to ADF, NDF and lignin. The ADF and NDF values obtained for the PPF from the large-scale factory (Table I) are similar to those reported by Vadiveloo and Fadel (1992) (556 and 783 g/kg). Furthermore, the lignin value observed for the large-scale factory processing unit concurs with the report of Jelan and colleagues (1986) (213 g/kg). The ash values observed were rather lower than that reported by Vadiveloo and Fadel (1992) (95 g/kg) but higher than the values of 29 g/kg and 56 g/kg reported by Jelan and colleagues (1986).

The higher fat content of PPF from the small-scale factory may be responsible for its lower dry matter and organic matter digestibilities. High levels of fat have been found to depress the digestibility of feedstuffs by inhibiting microbial activity during ruminal fermentation (McDonald et al., 1988; Orskov and Ryle, 1990).

The significant improvement in both the dry matter and the organic matter digestibilities of PPF from the small- and large-scale factory units when the PPF samples were defatted confirms the suggestion that its fat content accounted for the low digestibility of the PPF. The lower content of lignin in the PPF from the small-scale factory compared to that from the large-scale factory (Table I) may account for the greater improvement in both the IVDMD and the IVOMD of PPF from the small-scale factory over that from the large-scale factory (Table II). Lignin has been reported to have an inhibitory effect on the digestibility of feeds (Van Soest, 1994) as, apart from being very resistant to microbial attack, it prevents other nutrients from being attacked by ruminal microbes (Dehority et al., 1962; MacDonald et al., 1988).

The significant improvement in both the IVDMD and the IVOMD of PPF from both sources following treatment with 5% NaOH may be attributed to the breaking of intermolecular ester linkages in the PPF by the NaOH. The action of NaOH, hydrolysing intermolecular ester linkages, solubilizing hemicellulose and causing cellulose microfibrils to swell, enhances the penetration of ruminal microbes and increases the extent and rate of cellulose and hemicellulose digestion (Lesoing et al., 1981; Leng, 1992; Jung et al., 1993; Chaudhry and Miller, 1996; Chaudhry, 1997). The formation of an indigestible soap that might have affected the ability of the ruminal microbes to digest PPF probably accounts for the relatively small improvement in the digestibility of NaNW and NAD PPF. It has been reported (Devendra, 1978) that NaOH and calcium hydroxide form soaps with the oil in PPF and thus adversely influence its digestibility. The greater improvement observed in both the IVDMD and IVOMD for NaW PPF may be due to the indigestible soap being washed away by the water during treatment.

In conclusion, PPF is generally low in nitrogen but high in ether extract and lignin. Although defatting and chemical treatment of PPF with 5% NaOH improved both its dry matter and organic matter digestibility, these are still low (less than 0.400), suggesting a low feeding value. Further research into appropriate feed processing methods for PPF is required to increase its digestibility for efficient use as ruminant feed.
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REFERENCES


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