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Amount of Cassava Powder Fed as a Supplement Affects Feed Intake and Live Weight Gain in Laisind Cattle in Vietnam

Nguyen Xuan Ba*, Nguyen Huu Van, Le Duc Ngoan, Clare M. Leddin[1] and Peter T. Doyle[1]
Faculty of Animal Sciences, Hue University of Agriculture and Forestry, 102 Phung Hung, Hue City, Vietnam

ABSTRACT : An experiment was conducted in Vietnam to test the hypothesis that supplementation with cassava powder up to 2% of live weight (LW)/d (DM basis) would linearly increase digestible organic matter intake and LW gain of Laisind cattle. There were five treatments: a basal diet of elephant grass fed at 1.25% of LW and rice straw fed *ad libitum* or this diet supplemented with cassava powder, containing 2% urea, at about 0.3, 0.7, 1.3 or 2.0% LW. The cattle fed cassava powder at about 2.0% LW did not consume all of the supplement, with actual intake similar to the 1.3% LW treatment. Organic matter, digestible organic matter and digestible energy intakes increased (p<0.001) curvilinearly with increased consumption of cassava powder. Rice straw intake declined curvilinearly with increasing intake of cassava powder (p<0.001), and there was a small linear decline (p = 0.01) in grass intake. The substitution rate of cassava powder for forage was between 0.5 and 0.7 kg DM reduction in forage intake per kg DM supplement consumed, with no difference between treatments. Apparent digestibility of organic matter increased (p<0.001) in a curvilinear manner, while digestibility of neutral detergent fibre declined (p<0.001) in a curvilinear manner with increased consumption of cassava powder. Live weight gain increased (p<0.01) linearly with increased consumption of supplement. It was concluded that the amount of cassava powder fed should be limited to between 0.7 and 1.0% LW. (**Key Words :** Cassava Powder, Feed Intake, Growth Rate, Cattle, Vietnam)

INTRODUCTION

About 424,000 ha of cassava (*Manihot esculenta*) is grown in Vietnam, producing 6.6 million metric tonne (General Statistics Office, 2006), and it is used for starch manufacture and making chips or powder for feeding livestock. While much of the cassava is processed in commercial factories, farmers in rural areas also process the tubers and use cassava chips and/or powder as energy supplements for cattle. In Quang Ngai Province, Central Vietnam, Ba et al. (2005) found that cassava powder, rice bran and maize were the important supplements fed to cattle.

In this agro-ecological zone of Vietnam, most cattle graze native grasses during the day and are fed rice straw (*Oryza sativa*) at night for most months throughout the year (Ba et al., 2005). There are other systems where the basal feed includes cut and carry native grasses or sown species, such as elephant grass (*Pennisetum purpureum*), and where animals are largely kept in confinement. In general, native grass and rice straw will only meet the maintenance requirements of cattle, as they are usually low in metabolisable energy and protein.

To finish cattle for market or to increase condition for improved reproductive performance requires supplementation with energy-rich feeds, such as cassava powder, generally with a source of protein. Cassava powder is rich in starch, and concentrate supplements of this type can have negative associative effects when fed in significant quantities, whereby the digestibility of forage components are depressed (Mould et al., 1983b; Huhtanen, 1991). There is no published information from central Vietnam on the effects of different amounts of cassava powder on forage intake, diet digestibility and liveweight gain of Laisind cattle, a crossbreed of Red Sindhi and Vietnamese yellow cattle.

The hypothesis tested in the experiment reported here was that supplementation with cassava powder (and urea) up to 2% of liveweight (LW)/d would linearly increase digestible organic matter intake and liveweight gain of Laisind cattle.

* Corresponding Author: Nguyen Xuan Ba. Tel: +84-54-525-439, Fax: +84-54-524-923, E-mail: bao.nguyenxuan@gmail.com
[1] Future Farming Systems Research Division, Department of Primary Industries, Kyabram Centre, 120 Cooma Road, Kyabram, Victoria, 3620, Australia.
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MATERIALS AND METHODS

Experimental design and timetable

The experiment was conducted at Hue University of Agriculture and Forestry farm in Thua Thien Hue Province (16°00' to 16°48' latitude, 107°48' to 108°12' longitude) and had five treatments, namely:

- T1: basal diet (control) of elephant grass at 1.25% of LW (DM basis) fed between 0730 and 1800 h and rice straw at 40% above the previous day's intake from 1830 to 0700 h.
- T2: T1 plus 0.5 kg DM/d (about 0.3% of LW, DM basis, for a 150 kg live weight animal) of cassava powder.
- T3: T1 plus 1.0 kg DM/d (0.7% of LW, DM basis) of cassava powder.
- T4: T1 plus 2.0 kg DM/d (1.3% of LW, DM basis) of cassava powder.
- T5: T1 plus 3.0 kg DM/d (2.0% of LW, DM basis) of cassava powder.

The cassava powder had 2% urea added.

The experimental treatments commenced on 19 Mar. 2006 (day 1) and continued to day 88. The amount of supplement fed to each animal was adjusted each week to maintain the amounts offered at about 0.3, 0.7, 1.3 or 2.0% LW (DM basis). The amounts of supplement were chosen to cover the range likely in practice and to test if the response to supplementation in live weight gain was linear or curvilinear. For T2 and T3, the supplement was fed in 2 equal amounts at 07:15 h and 13:00 h, and the cattle generally consumed the entire supplement within 15 min. For T4 and T5, the supplement was fed in 3 equal amounts at 07:15 h, 13:00 h, and 16:30 h, and the residues were only collected in the morning. The supplement was fed in a separate feed bin to the forage.

Each animal had access to a hard mineral block, comprised primarily of salt, but containing 3% urea, 5% cottonseed meal, 5% molasses and a mineral premix. As the amount of block consumed daily was very small, no account has been taken of the intake of organic matter or nitrogen from this source. Water was freely available to each animal from a drinker within each pen.

Elephant grass was used in place of native grasses for logistical reasons and to have some uniformity in terms of species composition and nutritive characteristics in the basal diet. It was offered at about 1.25% LW (DM basis) to simulate limited availability of grass. As with the cassava powder, the amount offered to each animal was adjusted each week. The elephant grass was produced on land surrounding the university farm. It was harvested after 35 to 40 days regrowth in the late afternoon, transported to the animal house, and in the morning it was mechanically chopped to 5 to 10 cm lengths prior to feeding. Half of each animal's allocation was fed at 07:30 h, and the remainder was offered early afternoon at about 13:15 h. Grass residues were collected at 18:00 h each day.

On T1, rice straw was fed at 40% above the previous day's intake at 18:30 h and residues were collected at 07:00 h. For T2 and T3, the average amount of rice straw offered was 65% in excess of intake on the previous day, while for T4 and T5 the amount offered was over 200% in excess of the previous day's intake. Enough straw was purchased for the entire experiment from a village near Hue city, and was stored in a shed until used. The straw was mechanically chopped to 15 to 20 cm lengths. An objective of the experiment was to measure substitution rate of supplement for forage (grass plus straw) and it was important to maintain the same forage feeding practices across the treatments to see how much of the reductions in forage intake were due to decreased grass or straw intake. This obviously led to large differences in the amount of straw offered in relation to intake. There were only small differences in the chemical composition of straw offered and refused, as the straw was chopped prior to feeding.

The amounts of all feeds offered and residues were recorded daily. Sub-samples of each feed and of residues, when they occurred, were taken every day for DM determination during 3 digestibility periods (days 20 to 26, days 48 to 54 and days 76 to 82) with additional sub-samples taken for laboratory analyses.

Animals and management

Twenty growing entire male Laisind cattle about 15 to 18 months of age and weighing 164 (±19.1, SD) kg were used. The animals were blocked on the basis of live weight and condition score into groups of 5 and then allocated at random within each group to treatments. The cattle were adapted to the housing in individual stalls and feeding management for 14 days, during which time they were fed the basal forage diet plus 1.0 kg DM of the cassava powder supplement.

All animals were treated for internal parasites and liver fluke with Bioxinil (Bio Pharmachemie, Ho Chi Minh) and vaccinated for pasteurellosis with P15 vaccine (NaVetCo, Ho Chi Minh City) prior to the experiment. Cattle were weighed between 06:30 and 07:30 h before feeding on two consecutive days at the start and end of the experiment and at least once each week including at the start and end of each digestibility period.

Digestibility measurements

During digestibility measurement periods, sub-samples of feed and feed residues were collected daily, dried and stored for subsequent analyses. Faeces were quantitatively collected by hand immediately as or after an animal defaecated during these periods. The faeces collected each day was thoroughly mixed and sub-samples of about 5% taken for dry matter determination and for storage at -20°C. At the end of each period, faecal samples from each animal were mixed and dried at 60°C prior to chemical analyses. All samples were ground through a 1 mm screen in a mill (Retsche, Germany).

Urine was also collected daily from each animal using a plastic collection bag attached to a collection tube with a tap and suspended under the pissle by a harness. Whenever an animal urinated, the urine was immediately collected and added to a container containing 100 ml of 20% sulphuric acid solution. The pH was measured regularly and more acid added to keep the pH below 4.0.

Analytical procedures

Samples of feeds and faeces were analysed for dry matter, nitrogen, ether extract, and ash according to AOAC (1990). Crude protein concentration was calculated as N× 6.25. Gross energy of feeds and faeces was determined by bomb calorimetry (Bomb Calorimeter 6300, Parr Instrument Company). Neutral detergent fibre was determined as described by Van Soest et al. (1991). Urinary nitrogen concentration was measured by the Kjeldahl method (AOAC, 1990).

Hydrogen cyanide (HCN) concentration in cassava powder was measured after extraction using chloroform, distilling off the vapour into 5% potassium solution and titration with silver nitrate as described by Easley et al. (1970).

Calculations

Maximum and minimum temperatures, relative humidity and rainfall data were obtained from a weather station at the University farm. The temperature-humidity index (THI) was calculated as:

$$THI = td-(0.55-0.55RH)(td-58)$$

Where td is the dry bulb temperature in °F and RH is relative humidity expressed as a decimal (NOAA, 1976).

Live weight gain was estimated using regression analysis of weights collected during the experiment.

Substitution of supplement (kg DM reduction in intake of elephant grass plus rice straw (FI)/kg DM concentrate consumed) for forage was calculated for each animal receiving cassava powder as:

Substitution rate = (Average FI on T1-FI of each bull) /Concentrate intake of each bull)

Apparent digestibility of dry matter, organic matter, energy and crude protein and digestibility of neutral detergent fibre were calculated as intake minus faecal output divided by intake and converted to a percentage. Apparent nitrogen balance was calculated as nitrogen intake minus nitrogen excretion in faeces and urine.

Statistical analysis

Treatment effects for feed and nutrient intake and digestibility were tested using analysis of variance (ANOVA) using GenStat 9. There were 5 dietary treatments and digestibility period was used as a factor (treating as if it was a treatment) to test if there was an interaction between dietary treatment (amount of cassava powder consumed) and the digestibility period reflecting adaptation of animals to this supplement over time. Initial LW was used as a covariate. Where the effects of dietary treatments were significant, relationships between the amount of cassava powder actually consumed and intakes of feed or feed constituents or digestibility were examined. A polynomial contrast of order 2 (quadratic) was fitted to model the relationship between the measured variables and the amount of cassava powder. Residual diagnostics were performed after each analysis that showed the models fitted the data well.

Effects of dietary treatments on final LW and LW change were analysed using ANOVA in a completely randomised design. The same polynomial contrast was fitted to examine whether or not final live weight or live weight gain increased linearly with the amount of cassava powder consumed. Residual diagnostics were performed after each analysis that showed the models fitted the data well.

RESULTS

Environmental conditions and feeds

The average daily temperature was 27°C (range 21 to 32°C). The average relative humidity was 79% (61 to 96%). The calculated THI was on average about 79, with 39 days where the index was 80 or above, indicating a potential for significant heat stress, at least for temperate cattle.

The cassava powder was 86% DM, and there was little variation in the nutritive characteristics of this feed between the three digestibility periods. It contained on average (±std dev), organic matter 97.1(±0.28)% DM, neutral detergent fibre 8.3(±0.12)% DM, crude protein 1.7(±0.03)% DM, ether extract 0.3(±0.005)% DM, and gross energy 16.8 (±0.22) MJ/kg DM. The crude protein concentration increased to 8.3(±0.01)% DM with the addition of urea. The cassava powder contained 37 mg hydrogen cyanide/kg DM.

The nutritive characteristics of the elephant grass were also quite consistent throughout the experiment: namely organic matter 89.0(±2.17)% DM, neutral detergent fibre 71.5(±2.46)% DM, crude protein 10.8(±1.33)% DM, ether

Table 1. Dry matter (DM), organic matter (OM), crude protein (CP) and neutral detergent fibre (NDF) intake and digestibility in Laisind bulls fed Elephant grass and rice straw consuming different amounts of a cassava powder supplement

Intake of cassava powder (kg DM/d)	Treatment						Relationship	Sign. of relationship
	0	0.55	1.04	2.16	2.21	s.e.d.		
Elephant grass intake (kg DM/d)	1.80	1.86	1.79	1.80	1.58	0.159	Y = 1.81+0.07C	p<0.02
Rice straw intake (kg DM/d)	1.75	1.47	1.43	0.48	0.48	0.195	$Y = 1.72-0.18C-0.18C^2$	p<0.01
Substitution rate (kg DM/kg DM)		0.6	0.5	0.7	0.7	0.25		
OM intake (kg/d)	3.13	3.49	3.87	4.13	3.98	0.156	$Y = 3.10+0.96C-0.24C^2$	p<0.03
OM digestibility (%)	56.5	63.2	64.4	68.8	67.2	1.25	$Y = 56.9+11.1C-2.8C^2$	p<0.01
Digestible OM intake (kg/d)	1.76	2.21	2.49	2.84	2.67	0.116	$Y = 1.75+0.98C-0.24C^2$	p<0.01
Energy digestibility (%)	54.2	60.6	61.7	66.0	64.3	1.28	$Y = 54.6+10.6C-2.7C^2$	p<0.01
Digestible energy intake (MJ/d)	61.4	67.4	73.7	76.3	73.2	2.91	$Y = 60.9+16.5C-4.6C^2$	p<0.05
CP intake (kg/d)	0.28	0.32	0.35	0.40	0.38	0.014	Y = 0.28+0.09C	p<0.001
CP digestibility (%)	49.1	59.1	55.0	58.0	57.3	1.62	$Y = 50.3+11.0C-3.6C^2$	p<0.01
NDF intake (kg/d)	2.64	2.51	2.47	1.83	1.68	0.100	$Y = 2.61+0.01C-0.18C^2$	p<0.01
NDF digestibility (%)	62.3	61.3	58.5	46.2	41.3	2.04	$Y = 62.2+1.0C-4.4C^2$	p<0.01

Significant relationships between cassava powder intake (C) and different parameters are given.

Table 2. Liveweight, liveweight change, and nitrogen (N) intake, excretion in faeces and urine and apparent retention in Laisind bulls fed Elephant grass and rice straw consuming different amounts of a cassava powder supplement

Intake of cassava powder (kg DM/d)	Treatment						Relationship	Sign. of relationship
	0	0.55	1.04	2.16	2.21	s.e.d.		
N intake (kg/d)	0.045	0.051	0.056	0.064	0.061	0.0022	Y = 0.045+0.014C	p<0.001
Faecal N (kg/d)	0.023	0.021	0.025	0.027	0.026	0.0013	Y = 0.022+0.001C	p<0.001
Urinary N (kg/d)	0.009	0.009	0.008	0.009	0.008	0.0009		
Apparent N retention (kg/d)	0.013	0.021	0.023	0.029	0.027	0.0018	$Y = 0.013+0.001C-0.003C^2$	p<0.01
Initial liveweight (kg)	172	164	160	159	163	14.8		
Final liveweight (kg)	185	189	196	203	195	17.7		
Liveweight gain (kg/d)	0.22	0.35	0.43	0.59	0.47	0.079	Y = -26.5+259.2C	p<0.001

Significant relationships between cassava powder intake (C) and different parameters are given.

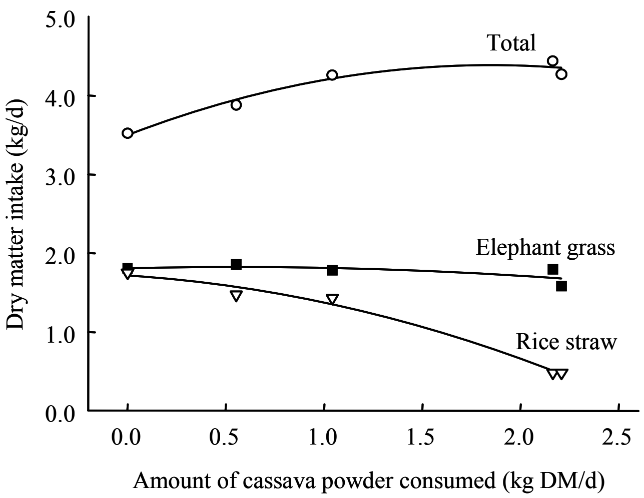

Figure 1. Effects of amount of cassava powder consumed on total intake (○), rice straw intake (∇) and elephant grass intake (■). Values are averages for intakes in 3 digestibility periods.

extract 2.3(±0.19)% DM, and gross energy 17.6 (±0.22) MJ/kg DM. The dry matter content of the grass was between 15 and 18%.

Rice straw (88% dry matter) also varied little in nutritive characteristics with organic matter 88.0(±1.53)% DM, neutral detergent fibre 77.1(±2.43)% DM, crude protein 5.1(±0.43)% DM, ether extract 1.6(±0.49)% DM, and gross energy 17.3(±0.23) MJ/kg DM.

Feed intake and digestibility

The amount of cassava powder consumed increased linearly from T1 to T4 (Table 1). While the amount of cassava powder fed was increased as LW increased through the experiment, the average intake for the three digestibility periods are reported in Table 1 and 2. The cattle fed cassava powder at an amount equivalent to about 2.0% LW for a 150 kg animal (T5) had feed refusals and actual intakes were similar (2.21 versus 2.16 kg DM/d) to T4. The intake of rice straw declined (p<0.001) curvilinearly with increasing intake of cassava powder (Figure 1), and while Elephant grass intake decreased (p = 0.01) linearly the effect was small. Total DM intake increased (p<0.001) curvilinearly as the amount of cassava powder consumed increased. There were no significant treatment by digestion period interactions for feed intake parameters. However, there were significant (p<0.01) period effects on total DM intake (3.81, 4.15, 4.26 kg DM/d in periods 1, 2 and 3, respectively, sed 0.130), primarily because the amounts of cassava powder and Elephant grass offered and consumed were increased as LW increased. Substitution rate of cassava powder for forage was not significantly affected by

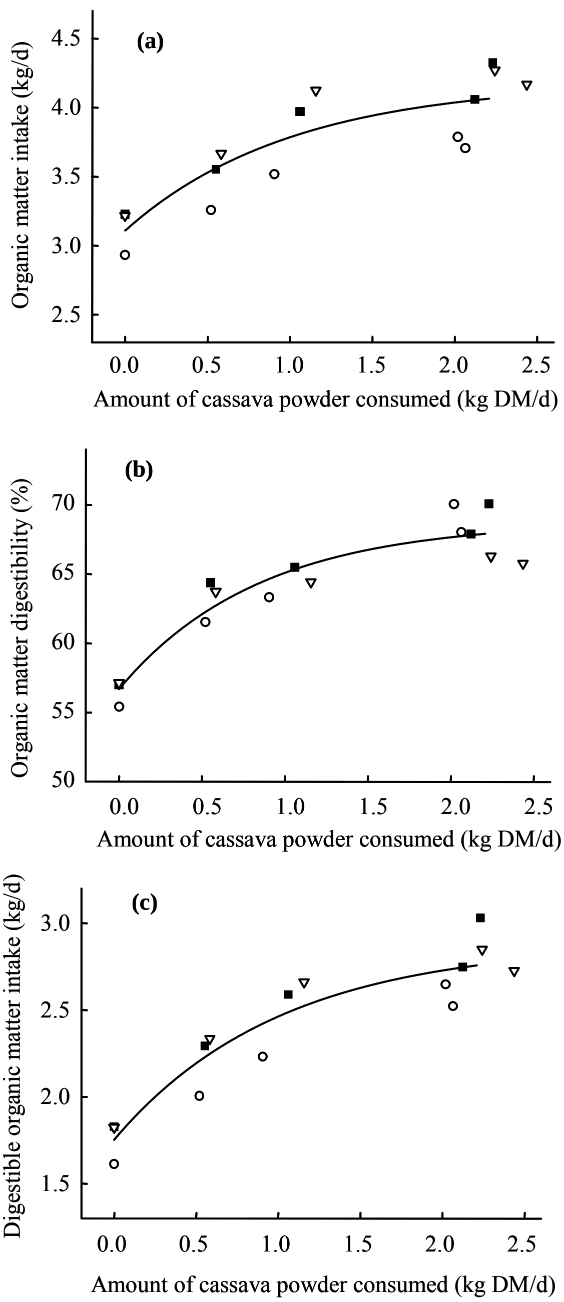

Figure 2. Effects of amount of cassava powder consumed on organic matter (a) intake, (b) digestibility, and (c) digestible intake. Data are for digestibility periods 1 (○), 2 (■), and 3 (∇).

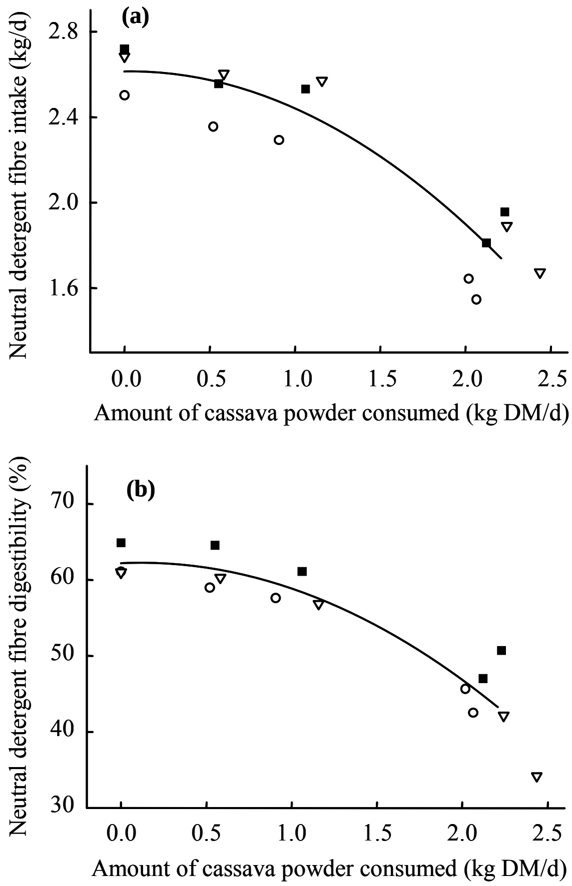

Figure 3. Effects of amount of cassava powder on neutral detergent fibre (a) intake, and (b) digestibility. Data are for digestibility periods 1 (○), 2 (■), and 3 (∇).

the amount of the supplement consumed (Table 1).

Organic matter and energy intakes, digestibility and digestible intakes increased ($p<0.001$) with curvature as the amount of cassava powder consumed increased (Table 1, Figure 2). Crude protein intake increased ($p<0.001$) linearly and crude protein digestibility increased ($p<0.001$) with curvature as the amount of cassava powder consumed increased. In contrast, neutral detergent fibre intake and digestibility declined ($p<0.001$) with curvature as the amount of cassava powder consumed increased (Figure 3).

There were no interactions or effects of period on apparent digestibility of organic matter or crude protein. There was a significant ($p<0.001$) effect of period on NDF digestibility, with period 2 having higher digestibility than periods 1 and 3 (57.7 versus 53.2 and 50.9%, respectively; sed 1.57).

Apparent nitrogen retention and liveweight gain

Nitrogen intake and faecal nitrogen excretion increased ($p<0.001$) linearly, while apparent nitrogen retention increased ($p<0.001$) curvilinearly as the amount of cassava powder fed increased (Table 2). There were no significant treatment effects on urinary nitrogen excretion. There were no significant treatment by period interactions for nitrogen intake or excretion. There were no significant differences between treatments in initial LW (Table 2). Liveweight gain increased ($p<0.01$) linearly as the amount of cassava powder fed increased, but final LW was not significantly different.

DISCUSSION

The hypothesis to be tested in the experiment reported here was that supplementation with cassava powder and urea up to 2.0% LW/d would increase LW gain of Laisind cattle in a linear manner. However, the animals on T 5 did not consume all of the cassava powder offered, and the response in weight gain was linear ($p<0.05$) in relation to the amount of cassava powder actually consumed. Failure to consume all of the powder on T5 could be due to a number of factors. Firstly, palatability or hydrogen cyanide toxicity may have been issues. As animals on T2 and T3 consumed all of the cassava powder offered in 15 minutes, it would seem that palatability was not a major issue. However, substitution rates at the low amounts of cassava powder were relatively high. The hydrogen cyanide intake on treatments T4 and T5 was about 80 mg/d or 0.5 mg/kg LW. Makkar (1991) reported that 2 to 4 mg hydrogen cyanide/kg LW were toxic for cattle. Thus, while we cannot discount effects of palatability or hydrogen cyanide on intake, it appears they may be small. Secondly, the effects of cassava powder on neutral detergent fibre digestibility indicate that rumen pH was low and that rumen fermentation was unstable. Cassava powder has starch concentrations greater than 80% DM (Vearasilp and Mikled, 2001), and the digestibility of starch from cassava tubers is high, about 99% (Tudor and Norton, 1982). Thus, at the higher intakes rapid fermentation of the supplement may have led to subacute rumen acidosis. Starch containing supplements reduce not only rumen pH, but also cellulolytic activity (Terry et al., 1969; Osbourn et al., 1970) and the lower NDF digestibility on T4 and T5 indicates that sub acute rumen acidosis may have been an issue. This is consistent with similar studies in ruminants when they have been fed with different amounts of cassava chip or different amounts of concentrate containing high level of cassava chip (Chajula et al., 2007; Phengvichith and Ledin, 2007; Wanapat and Khampa, 2007). It would seem that in practice, supplementation with cassava powder should be limited to between 0.7 and 1.0% LW, and that lower amounts mixed with other available supplements, such as maize and rice bran (Ba et al., 2005), would be a safer strategy.

Substitution occurs when concentrates are fed to ruminants grazing pastures or fed *ad libitum* on conserved forages and generally ranges between 0 and 1.0 kg DM/kg DM (Stockdale et al., 1997; Heard et al., 2004). In the current experiment, estimated substitution rates were relatively high at all amounts of cassava powder consumption (Table 1). In grazing cows, substitution rates are variable, as was the case in this experiment, and they usually increase with the amount of pasture consumed or with the amount of concentrate supplement consumed (Stockdale, 2000; Wales et al., 2006). It has been hypothesised that substitution may be caused by negative associative effects in the rumen where interactions between the digestion of concentrates and pasture reduce the rate of fibre digestion (Dixon and Stockdale, 1999). While substitution rate may be influenced in part by negative associative effects, other factors, such as the animal's preference for feeds, are also likely to be involved.

In this experiment, neutral detergent fibre digestibility was depressed from 62 to 41% as the amount of cassava powder consumed increased. This occurred even though straw intake and the intake of less readily digestible neutral detergent fibre declined. There is evidence that the digestibility of neutral detergent fibre in mature forages may be depressed more than that of fresh herbages when the rumen environment is altered by feeding concentrates (Mould et al., 1983b; Huhtanen, 1991). This influence of starch containing supplements is mediated through reductions in rumen pH and cellulolytic activity (Terry et al., 1969; Osbourn et al., 1970). The critical rumen pH below which digestion of structural carbohydrates is reduced varies between 6.2 (Grant and Mertens, 1992) and 6.0 (Mould et al., 1983a). The consequence of these effects is that estimated metabolisable energy contents of forage overestimate the amount of metabolisable energy actually derived by the animal (see Doyle et al., 2005), which would be the case in this experiment where neutral detergent fibre digestion was depressed.

Importantly, not only do forages and their structural carbohydrates vary in their susceptibility to associative effects, but the type of concentrate, their level of starch and starch degradation characteristics are important (Knowlton, 2001). Cereal grains vary in their rates of *in vitro* fermentation: wheat>triticale>oats>barley>maize>rice and sorghum (Opatpatanakit et al., 1994), and wheat and barley inhibit neutral detergent fibre digestion *in vitro* to a greater extent than maize (Opatpatanakit et al., 1995). High levels of rapidly degradable starch in cassava powder are more likely to cause intensive production of lactate and rapid reduction in ruminal fluid pH compared with feeds containing slowly degradable, crystalline starches, such as maize (Opatpatanakit, 1994). The depression in neutral detergent fibre digestibility by cassava powder was significantly greater than has been reported in growing Friesian cattle fed late-cut perennial ryegrass silage with rolled barley at 280 or 560 g/kg total DMI (neutral detergent fibre digestibility reduced from 65 to 56%) (Beever et al., 1988; Thomas et al., 1988).

Despite these effects of cassava powder on forage intake and digestion, digestible organic matter and digestible energy intakes increased with amount of the supplement consumed, as did live weight gain. This is consistent with similar studies in ruminants where forages have been supplemented with starch containing feeds (Mulholland et al., 1976; Thomas et al., 1988). In practice, farmers in central Vietnam should be advised that while supplementation with cassava powder and urea as a sole supplement will increase live weight gain, it is prudent to limit the amount fed to between 0.7 and 1.0% LW to limit wastage, and to avoid potential for rumen dysfunction and depressions in forage digestion. This supplement would be better incorporated in mixtures with maize or rice bran which are more slowly digested.

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