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A Comparative Study on the Effect of Cassava Hay Supplementation in Swamp Buffaloes (*Bubalus bubalis*) and Cattle (*Bos indicus*)

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ABSTRACT : Twelve swamp buffaloes and Brahman cattle heifers (6 animals each) were randomly assigned to two treatments, control (grazing only) and supplementation of cassava hay (CH) at 1-kg dry matter per head per day (DM/hd/d), in a 2×2 factorial arrangement according to a cross-over design. The cassava hay contained a high level of protein (19.5% of DM) and a strategic amount of condensed tannins (4.0% of DM). As a result it was revealed that supplementation of CH at 1-kg DM/hd/d significantly ($p<0.05$) improved the nutrition of both swamp buffaloes and Brahman cattle in terms of DM, organic matter (OM), protein and energy intake and digestibility, ruminal NH_3-N and rumen ecology. Supplementation significantly ($p<0.05$) reduced weight losses in both species and improved the health, in terms of reduced number of parasite eggs in feces ($p<0.05$), of both buffaloes and cattle. There tended to be a difference in term of response to CH between the two species. The DM, OM, protein intake and digestibility and total digestible energy intake tended to be higher for buffaloes as compared to cattle. Moreover, the percentage reduction of parasite eggs tended to be higher for buffaloes as compared to cattle (57.6 and 45.0%, respectively). However, there were no significant interactions between species and treatments. (**Key Words :** Ruminants, Cassava Hay, Protein Supplementation, Condensed Tannins, Fecal Parasitic Eggs Count, Swamp Buffalo, Beef Cattle, Grazing, Digestibility)

INTRODUCTION

In the tropics, likewise in Thailand, buffaloes and cattle are raised as an integral part of the crop production system, especially where rice is the main commodity (Chantalakana, 2001). According to Wanapat (1995) buffaloes are raised in subsistence systems and beef cattle in semi-intensive systems utilizing grazing and supplementation with on-farm resources. Farmers raise cattle for sale while buffaloes are raised for draft power as well as for sale thereafter. Wanapat et al. (1999) and Kennedy and Hogan (1994) have reviewed the major differences between buffaloes and cattle in terms of nutrition, it was found that buffaloes could utilize feed more efficiently, particularly where the feed supply is of low quantity and/or quality, with the digestibility of feed being typically 2-3 percentage units higher than cattle. Wanapat et al. (2000b) suggested that this may be explained that buffaloes had a different rumen ecology than that in cattle by means of having higher population of cellulolytic bacteria and fungal zoospores and the ability to recycle nitrogen to the rumen.

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An inadequate feed supply is one of the most limiting constraints for livestock growth, reproduction and production in Thailand (Wanapat and Devendra, 1999). Forage quality is important in the context of digestibility and the requirement for additional nutrients. It has been found that buffaloes and cattle raised under village condition suffer from nutritional adequacy during periods with low forage quantity and/or quality (Scholz et al., 1989). The very low nitrogen intake makes energy use less efficient, and considerable protein catabolism occurs to meet energy requirements. Under these conditions the animals may also be more susceptible to infectious or parasitic diseases.

Recently, cassava hay (*Manihot Esculenta*, Crantz) has been growth as a protein foliage supplement in ruminant nutrition especially for dairy cattle and also in beef and buffalo production (Wanapat, 1993; Wanapat et al., 2000a; 2000b; Khang et al., 2005). The use of cassava hay was successfully implemented in several ways by either direct feeding or as a protein source in concentrate mixtures (Wanapat et al., 2000ab; Hong et al., 2003; Kiyothong and Wanapat, 2004ab), as component in soybean meal and urea pellets (Wanapat et al., 2006) and as ingredient in high quality feed blocks (Wanapat and Khampa, 2006). Cassava hay consists of whole crop of cassava harvested at 4 months of growing. The stem with leaves is cut into 3-5-cm pieces and then sun-dried for 2-3 days to attain DM of about 80-90% (Wanapat et al., 1997). Cassava hay contains a high level of protein (25% of DM in average) and a strategic amount of condensed tannins (4% of DM in average) according to Wanapat et al. (1997). Condensed tannins (CT) are secondary plant compounds (polyphenolics) that react with protein in the saliva of ruminants when ingested (pH>3). The tannin-protein complex bypasses the rumen and is released at a low pH (<3) in the lower gut (Hagermann and Butler, 1981). Thus CT contributes to a higher level of protein in the small intestine. Cassava hay fed at 1 kg/hd/d could reduce the number of parasitic eggs in buffaloes and cattle (Netpana et al., 2001). Several hypothesis have been proposed that CT has a direct and indirect effect on parasites in ruminants (Athanasiadou et al., 2000; Molan et al., 2000), although the mode of action of condensed tannins on parasitic larvae and eggs are not yet elucidated. Hoskin et al. (2000) hypothesized that CT could interact with the protein surface of immature and adult nematodes residing in the gastrointestinal (GI) tract and reduce parasite motility or influence host/parasite interactions. The indirect effect of CT towards gastrointestinal parasites is evoked through protein nutrition of the host (Bown et al., 1991). Bown et al. (1991) showed that an infusion of protein into the abomasums of lambs trickle-infected with *T. colubriformis* resulted in reduced worm numbers and improved lamb performance. This research was conducted to further establish the effect of cassava hay on nutrition, performance and health in cattle and swamp buffaloes during grazing and also to compare the response of treatments between buffaloes and cattle.

MATERIALS AND METHODS

Animals, diets and experimental design

The experiment was conducted at the Beef Unit in Khon Kaen University, Thailand, over two periods during three months. Six heifers Brahman cattle and six heifers swamp buffaloes were randomly assigned to receive two treatments, control (non-supplementation) or supplementation of cassava hay at 1 kg DM (2 times daily) in a 2×2 factorial arrangement according to a Cross-over design.

All the animals were grazing during the daytime (from 10 a.m. to 4 p.m.) and were raised in individual pens over the night with free access to water and mineral blocks. In the morning and afternoon the animals receiving supplementation were fed cassava hay according to the respective treatments.

Data collection and sampling procedures

The animals were sampled for feces by rectal sampling every 14 days. The feces were stored in a refrigerator and were analysed for parasitic eggs by the McMaster counting technique (Hansen and Perry, 1990; Zajac, 1994).

During the last two weeks of each period all the animals were fed 15 g Cr_2O_3 (an external marker), mixed with 15-g rice bran, to estimate the total feces production of each individual animal (Galyean, 1989). The last 7 days of each period feces were collected by rectal sampling from each individual animal. The total feces production was estimated by the following equation of Galyean (1989) with analyzed Cr_2O_3 in feces of each individual animal according to the method of AOAC (1985).

Acid detergent lignin (ADL) was used as an internal marker to estimate intake of pasture and digestibility of feed according to Galyean (1989). The intake of pasture and total DM digestibility for each individual animal were calculated according to the method of Galyean (1989).

Digestible protein intake, metabolizable energy intake and protein to energy (P/E) ratio were calculated as per Kearl (1982). The live weight of each individual animal was recorded at the first and last day of each period, and the weight change (g/hd/d) was calculated at the end of the experiment. Cassava hay (CH) was prepared as reported by Wanapat et al. (1997, 2000c). CH and pasture were sampled regularly during the experimental periods and analyzed for DM and chemical composition. NDF and ADF were analyzed according to the procedure of Van Soest et al. (1991) meanwhile condensed tannin was analyzed by the Vanillin-HCl method of Burns (1971) as modified by Wanapat and Poungchompu (2001). Total nitrogen was analyzed by the standard Kjeldahl procedure (AOAC, 1985).

Rumen fluid was taken from the middle part of the rumen by a stomach tube connected with a vacuum pump at each time at the end of each period. Rumen fluid samples were then filtered through four layers of cheesecloth and fixed with10% formalin solution in normal saline for determined total count of bacteria, protozoa and fungal zoospores were measured based on the use of a haematocytometer (Boeco) were made using the methods of Galyean (1989).

Statistical analysis

The data were analyzed by PROC GLM (SAS, 1998) and Least Square Means (Steel and Torrie, 1985) were used to compare treatment means.

RESULTS AND DISCUSSION

Chemical composition

Table 1 shows the chemical composition of cassava hay (experimental feed) and the mixed pasture (basal feed)

Table 1. Chemical composition of cassava hay (CH) and mixed pasture*

Items	DM	Ash	CP	NDF	ADF	ADL	CT
	% DM						
Cassava hay	91.4	5.7	18.5	63.8	47.9	11.9	4.0
Rainy season (P1)	91.3	8.3	19.5	55.2	35.3	8.1	4.7
Dry season (P2)	91.4	7.0	19.0	59.5	41.6	10.0	4.3
Mixed pasture*	61.6	6.8	9.6	77.0	48.6	7.4	-
Rainy season (P1)	76.2	7.4	5.9	82.0	49.6	9.6	-
Dry season (P2)	68.9	7.1	7.2	79.5	45.6	8.5	-

* *Brachiaria Ruziensis* and native grasses; DM = Dry matter; CP = Crude protein; NDF = Neutral detergent fiber; ADF = Acid detergent fiber. ADL = Acid detergent lignin; CT = Condensed tannins; P1 = Experimental period one; P2 = Experimental period 2.

Table 2. The effect of cassava hay supplementation on DM, CP, TDP and ME Intake, DM and CP digestibility, P/E- ratio and live weight change in swamp buffaloes and cattle

Items	Buffaloes		Cattle		SEM	Effects		
	C	S	C	S		A	B	A×B
Mean live weight (kg BW)	360.0^{a}	363.0^{a}	312.0^{b}	316.0^{b}	6.3	***	NS	NS
DM intake								
Cassava hay (g/kg BW$^{0.75}$/hd/d)	-	12.6^{a}	-	13.3^{b}	0.3	NS	-	-
Pasture (g/kg BW$^{0.75}$/hd/d)	57.9^{a}	56.0^{ab}	54.4^{ab}	47.5^{b}	2.9	NS	NS	NS
Total								
kg/hd/d	4.8^{a}	5.7^{b}	4.1^{a}	4.6^{a}	0.2	**	*	NS
g/kg BW$^{0.75}$/hd/d	57.9^{ac}	68.6^{b}	54.4^{c}	60.8^{abc}	3.0	NS	*	NS
CP intake								
Cassava hay (g/kg BW$^{0.75}$/hd/d)	-	185.4	-	177.4	3.6	NS	-	-
Pasture (g/kg BW$^{0.75}$/hd/d)	347.16^{a}	343.1^{a}	306.4^{ab}	256.9^{b}	18.4	*	NS	NS
Total								
g/hd/d	4.2^{a}	6.3^{b}	4.1^{a}	5.8^{b}	0.2	NS	***	NS
g/kg BW$^{0.75}$/hd/d	347.16^{a}	528.5^{b}	306.4^{a}	434.3^{c}	19.7	*	***	NS
DM digestibility (%)	27.2^{a}	42.4^{b}	39.6^{b}	42.1^{b}	2.6	*	**	*
CP digestibility (%)	52.3^{ac}	64.1^{b}	49.6^{c}	59.6^{ab}	2.2	NS	**	NS
TDP intake (g/hd/d)	193.4^{a}	344.8^{b}	171.7^{a}	260.5^{c}	16.2	*	***	NS
ME intake (MJ/hd/d)	26.3^{a}	37.9^{b}	24.2^{a}	28.3^{a}	2.4	NS	*	NS
P/E-ratio (g/MJ)	7.1^{a}	9.0^{b}	6.3^{a}	9.4^{b}	0.3	NS	***	NS
Live weight change (kg/hd/day)	-0.2^{a}	-0.1^{b}	-0.3^{a}	0.02^{c}	83.6	NS	*	NS

$^{a, b, c}$ Values on the same row with different superscripts differ ($p<0.05$).

* $p<0.05$, ** $p<0.01$, *** $p<0.001$.

NS = Non-significant; values are the mean of 6 animals; C = Control; S = Cassava hay supplementation.

A = Species (buffalo or cattle). B = Dietary treatment (0 or 1 kg DM CH); A×B = Interaction between species and dietary treatments.

CP = Crude protein; TDP = Total digestible protein; ME = Metabolizable energy.

P/E = Protein to energy; BW = Body weight; g/kg BW$^{0.75}$/hd/d = g nutrients per kg metabolic body weight per head per day.

SEM = Standard error of the mean.

during the two experimental periods. The CH and mixed pasture differed in chemical composition between the two periods.

The mean level of crude protein (CP) in cassava hay during the experiment (19% of DM) was lower than the standard mean value of 23.5%, as reported by Wanapat et al. (2000b). The lignin and condensed tannins (CT) fraction were higher during the first and second period respectively (11.9 and 4.7% of DM) as shown in Table 1. However the neutral detergent fiber (NDF) and acid detergent fiber (ADF) were in accordance with the previously reported values for CH. The mean value of CT in cassava hay was measured to be between 4.0 and 4.7% of DM (Table 1) for the first and second period respectively.

The mixed pasture consisting of Ruzi grass ans native grass was of low quality in term of low CP but high in fiber as well as lignin fractions (6.9, 82 and 9.6% of DM respectively) during the second period, from the end of December until mid-February, as compared to the first period (Table 1). The regrowth of the grasses was limited in this period, so the quantity of the pasture was also low.

Intake, digestibility and live-weight change

Cattle and buffaloes have a different physiology in terms of live-weight gain at the same stage of growth (Johnson and Charles, 1975). According to Kearl (1982), the two species mature at a different age relative to body size, and depending on nutrition, genetics and environment. These animals were between 2.5 and 3 years at the beginning of the experiment.

Intake of CH was restricted for both buffaloes and cattle at 1 kg DM/hd/day. The intake of pasture, in terms of % of BW, was higher for the swamp buffaloes as compared to the cattle. Furthermore, the total DM intake, in terms of % of BW, was significantly ($p<0.05$) higher for both the swamp buffaloes and the Brahman cattle that received supplementation as compared to the grazing animals. Moran et al. (1983) reported that DM intakes of rice straw in both Zebu cattle and buffalo were higher when supplemented with Leucaena.

DM digestibilities of CH and pasture were significantly higher ($p<0.05$) for the buffaloes as compared to the cattle. As reported in other work that buffaloes could digest 2-5% more of each nutrient than cattle when fed low quality roughages (Moran et al., 1983; Kennedy and Hogan, 1994). The DM digestibility of pasture was significantly improved ($p<0.05$) for both buffalo and cattle which were supplemented with CH at 1.0 kg DM/hd/d (Table 2). However, in cattle the DM digestibility was higher than in buffalo in the unsupplemented group. Strategic supplementation of CH has been reported to manipulate the rumen, in terms of having higher pH, improving rumen ecology and enhancing by-pass protein (tannin-protein complex) and hence could improve DM digestibility of low quality feed (Wanapat, 2000a). Furthermore, manipulation of the rumen by supplementation of CH could increase intake of low-quality forages and improve productivity of ruminants in terms of milk yield and weight gain (Wanapat, 1993; Wanapat et al., 2000b).

Table 2 shows that all the animals (except the supplemented Brahman heifers) lost weight during the experiment. However the animals that received CH at 1 kg/hd/d maintained their weight better as compared to the non-supplemented group. The unbalance in nutrient intake in comparison to the minimum requirement of buffaloes and cattle for growth (Kearl, 1982) may explain the weight loss. The balance between protein and energy (P/E ratio), as shown in Table 2, were lower than the requirement for the grazing animals, while those receiving CH supplementation were within the minimum range (Kearl, 1982). CH supplementation improved the balance between protein and energy and hence could compensate for the weight loss. Forages containing condensed tannins (CT) have been reported beneficial in ruminants in terms of enhanced protein nutrition and weight gain (Niezen et al., 1995; 1996).

The low quantity and quality of the pasture in the dry season, in terms of productivity and chemical composition of the forage, may have attributed to the loss of weight for the grazing animals (with no supplementation). McDowell (1985) reported that the lowered protein content and significantly reduced forage intake during the dry season in grazing ruminants, and that inadequate protein and energy resulted in weight loss. Furthermore, it has been reported that the pathophysical consequences of parasitism are more severe in animals on lower plane of nutrition, as protein supply is diverted away from the body growth towards the repair, replacement and reaction to gut damage, or to endogenous loss of protein (Coop and Holmes, 1996).

Rumen microbial ecology

Table 3 shows the effect of CH supplementation on rumen ecology. The number of bacteria tended to be higher in the rumen fluid of the supplemented animals as compared to those grazing only, especially at 4 h post feeding. The numbers of fungi (fungal zoospores) were significantly higher in the rumen fluid of the buffaloes, and tended to be higher for the supplemented cattle. The numbers of protozoa tended to be decreased in all the

Table 3. Effect of cassava hay supplementation on total microbial count (cells/ml) in rumen fluid of swamp buffaloes and cattle

Total microbial count (cells/ml)	Buffaloes		Cattle		SEM	Effects		
	C	S	C	S		A	B	A×B
Bacteria ($\times 10^9$)								
0 h post feeding	3.0^a	5.7^b	5.1^b	4.9^{ab}	0.6	NS	NS	*
4 h	4.7	10.0	7.6	9.7	1.9	NS	*	NS
Mean	3.9^a	7.9^b	6.4^b	7.3^b	1.0	NS	*	NS
Protozoa ($\times 10^4$)								
0 h post feeding	3.1^{abc}	2.4^b	4.2^c	3.8^{ac}	0.3	**	NS	NS
4 h	4.1	3.6	4.8	4.2	0.6	NS	NS	NS
Mean	5.2	4.8	5.3	4.5	1.2	NS	NS	NS
Fungi ($\times 10^5$)								
0 h post feeding	14.7^a	12.8^a	1.7^b	1.6^b	4.0	NS	NS	NS
4 h	13.2^a	36.6^b	2.0^a	2.9^a	8.4	*	NS	NS
Mean	11.7^a	60.3^b	2.3^a	4.2^a	17.1	*	NS	NS

[a, b, c] Values on the same row with different superscripts differ ($p<0.05$).

* $p<0.05$, ** $p<0.01$, *** $p<0.001$.

NS = Non-significant; Values are the mean of 6 animals. C = Control; S = Cassava hay supplementation.

A = Species (buffalo or cattle). B = Dietary treatment (0 or 1 kg DM CH).

A×B = Interaction between species and dietary treatments; 0 h = sampling at 0 h post feeding; 4 h = sampling at 4 h post feeding.

Cells/ml = Number of microbial cells per ml rumen fluid; SEM = Standard error of the mean.

Table 4. Effect of cassava hay supplementation on fecal parasitic egg counts (FPEC)

Fecal eggs counts (eggs/g DM feces)	Buffaloes		Cattle		SEM	Effects		
	C	S	C	S		A	B	A×B
Preliminary period	1,552	1,243	1,189	1,462	166.1	NS	NS	NS
Experimental period	918 [ac]	579 [b]	951 [c]	747 [ab]	56.0	NS	***	NS

[a, b, c] Values on the same row with different superscripts differ ($p<0.05$).

* $p<0.05$, ** $p<0.01$, *** $p<0.001$.

NS = Non-significant; Values are the mean of 6 animals. C = Control; S = Cassava hay supplementation.

A = Species (buffalo or cattle); B = Dietary treatment (0 or 1 kg DM CH);

A×B = Interaction between species and dietary treatments. SEM = Standard error of the mean.

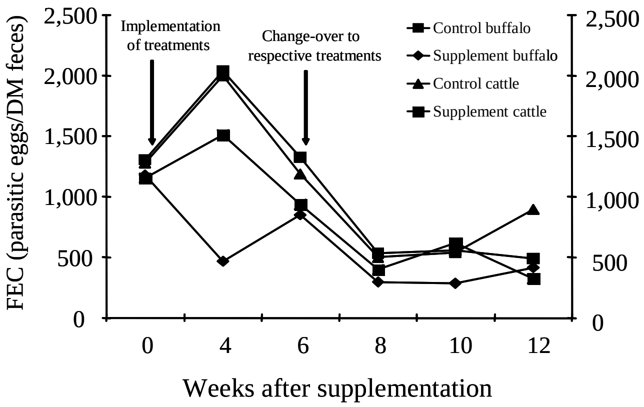

Figure 1. The effect of cassava hay supplementation on fecal parasitic egg counts (FPEC) in the buffaloes and cattle during the two experimental periods.

supplemented animals, especially at 4 h post-feeding. This is in accordance with the findings of Wanapat et al. (2000c) who stated that microbial ecology and growth is dependent on the feeding strategy, the pH and available substrates in the rumen. Cassava hay supplemented may have provided the rumen with effective fiber and the condensed-protein complex which could have stimulated the bacterial growth and subsequent fermentation in the rumen.

Fecal parasitic eggs count (FPEC)

The preliminary fecal egg counts (FPEC) indicated that all the animals had a high infestation of parasites and the numbers of eggs within blocks and between blocks were similar (Table 4).

The difference between the two treatments were highly significant ($p<0.001$), as shown in Table 4), and all the animals that received cassava hay supplementation had the lowest number of parasitic eggs during the experimental periods (Table 4 and Figure 1). This difference indicates that the cassava hay had an effect on parasitic eggs count as previously reported by Netpana et al. (2001). It may be caused by the condensed tannins (CT) in the cassava hay directly (Anthanasiadou et al., 2000; Molan et al., 2000) or indirectly in terms of enhanced protein supply to the small intestine associated with tannins (Bown et al., 1991; Wanapat, 2000b).

Condensed tannins (CT) of quebracho extract had a direct anthelmintic effect on an established *T. colubriformis* population when it was given as a drench to parasitised sheep (Athanasiadou et al., 2000). Molan et al. (2000) found that CT extracted from *Lotus pedunculatus, L. corniculatus,* sulla (*Hedysarum coronarium*) and sainfoin (*Onobrychus vicifolia*) had inhibitory activity on larvae of deer lungworms (*Dictyocaulus sp.*) and gastrointestinal nematodes as measured by their ability to paralyze the larvae and inhibit them from passing through sieves. The mechanism by which the tannins inhibit larval migration is not yet known, however it has been suggested that CT could interact with the protein surface of immature and adult nematodes residing the GI tract and reduce parasite motility or influence host/parasite interactions (Hoskin et al., 2000).

The CT containing forages have been reported to increase the protein availability in the small intestine of ruminants (Niezen et al., 1996). Under this study similar result was found and it could be due to higher protein availability provided by CH in the form of tannins-protein complex. Long-term studies showed that feeding high protein diets containing bypass protein to animals infected *with Ostertagia circumcincta* or *Trichostrongylus* spp. increased the expression of acquired immunity and reduced production losses due to parasititsm (Blackburn et al., 1991; Bown et al., 1991; Coop et al., 1995). Bown et al. (1991) suggested that casein infusion permitted the host to limit the size of infection through the development of an effective immune response. However the response in terms of lower nematode burdens became apparent only from about 7-10 weeks post infection (Bown et al., 1991).

During the rainy season the number of eggs was very high (until week 16), while it was reduced successively from week to week during the experimental period (Figure 1). During the experimental period the number of parasitic eggs was reduced for all animals when the season proceeded from late rainy in November to early dry season in January (Table 3 and Figure 1). During the second period of the experiment (from week 18) the number of parasitic eggs was more than halved. This may be affected by the seasonal effect on the life cycle of the parasites in ruminants. Horchner et al. (1989) reported seasonal variation of liver fluke infection in animals and in intermediate host in Northeastern Thailand. Infection of animals could be found throughout the year, mostly in September. Furthermore, the cercarial infection rate (*Fasciola cercaria*) from the intermediate snail host (*Lymnea rubiginosa*) increased to 30% in November and reached the highest peak of 33% at the beginning of December, in the end of the rainy season (Srikitjakarn, 1989).

It was also interesting to notice the difference in FPEC between the supplemented buffaloes and cattle. Buffaloes tended to have the least numbers of parasitic eggs and also the highest percentage reduction from the preliminary period (Table 3 and Figure 1). This indicates that there may be a difference between buffaloes and cattle with their abilities in maintaining their health and the resistance to the internal parasitic infection, however, further work should be substantiated.

Previously, several studies have revealed differences between buffaloes and cattle in terms of digestion, metabolism, microbial population in rumen and physiological responses (Kennedy and Hogan, 1994; Wanapat et al., 1999; Wanapat et al., 2000d).

The cassava hay contained a high level of protein and a strategic amount of condensed tannins (4.0% of DM). The buffaloes and cattle that received CH supplementation maintained their weight better than the animals that were grazing only. Moreover, CH could improve the nutrition of the Brahman heifers and swamp buffaloes in terms of DM digestibility of the low quality forage. The cassava hay had a significant effect on the parasitic infestation, in terms of lower egg counts. Furthermore, buffaloes tended to have lower egg counts and higher percentage reduction of parasitic eggs as compared to the cattle. As previously postulated the CT in addition to the high protein level may have a direct and indirect effect on fecal egg counts and CH could hence be utilized as a non-chemical anthelmintic in buffalo and cattle production.

Cassava hay is a suitable crop for small-holder farmers in the Northeast of Thailand as it could be established on-farm and utilized as a protein supplementation as well as a non-chemical anthelmintic in ruminant production. This could reduce expenses for feed as well as for veterinary medicine and moreover enhance the production of the animals. From an ecological point of view, cassava hay may reduce the utilization of chemicals in ruminant production and decrease the loss of nitrogen to the environment, in terms of improved feed efficiency. However, further research should be conducted on the effect of different levels of cassava hay on nutrition, performance and health in buffaloes and cattle.

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