UTILIZATION OF CROP BY-PRODUCT OPTIONS IN SMALLHOLDER CATTLE PRODUCTION SYSTEMS IN VIETNAM

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ABSTRACT

The most common system of beef cattle production is extensive grazing system (usually 1 to 2 head) that is practiced by smallholder farmers in Northern Mountains and Central regions, accounted for 70%-80% of beef cattle in Vietnam. This system requires little labour as farmers normally do not feed their cattle with compound, concentrate or manufactured. Seasonal crop by-products, e.g. rice straw, are often used to feed cattle at night, especially in the winter. Farmers generally use cattle for draught purposes and keep them as a source of savings. This low input system is characterised by low output and poor reproductive performance. However, to move cattle production system from extensive to semi-intensive and intensive systems, animal management, together with feed and feeding systems are needed to be solved. Based on a thorough review of the literature, it is important to understand the current animal, feed, shelter and health management practices in order to chart innovative directions and strategies for further beef cattle research and development in mountainous areas of Vietnam. Research priorities on beef cattle production should be concerned on feed, feeding and management of finishing (fattening) cattle, cow-calf production, weaned calf and pregnant cows to shift from extensive and more intensive systems.

Keywords: *Beef cattle, crop by-products, feed, smallholder farmer, extensive system, intensive system*

INTRODUCTION

The cattle population in Vietnam increased from 5.23 in 2014 to 5.80 million heads in 2018, representing an average annual growth rate of 10.90% (GSO, 2014-2018). The cattle production in this province is mainly in the northern central and central coast region with 2.37 million heads, accounting for 40.86% and the northern midland and mountainous region with 1.02 million heads, accounting for 17.59%. Beef production in 2018 was about 409.60 thousand tonnes, increased to 38.69 tonnes compare to 2014, with the average annual growth rate of 7.74% for the period 2014-2018. According to Luong Pham et al. (2015), the most common system of beef cattle production is extensive grazing system (usually 1 to 2 head) that is practiced by smallholder farmers in Northern Mountains and Central regions, accounted for 70%-80% of beef cattle in Vietnam. This system requires little labour as farmers normally do not feed their cattle with compound, concentrate or manufactured. Seasonal crop residues, e.g. rice straw, are often used to feed cattle at night, especially in the winter. Farmers generally use cattle for draught purposes and keep them as a source of savings. This low input system is characterised by low output and poor reproductive performance. Cattle production systems tend to move from extensive to semi-intensive and intensive systems (Ba et al., 2015). However, to fully utilize this opportunity, several impediments needed to be solved, such as animal management, together with feed and feeding systems. Therefore, utilization of crop by-products in smallholder cattle production systems in Vietnam have been mentioned in this literature review.

Available agricultural by-products for cattle feed in Vietnam

The annual average yield of paddy, maize, cassava and sweet potato in the period 2014-2018 in Vietnam were around 40.000 thousand tonnes; 5.200 thousand tonnes; 10.200 thousand tonnes; 1.350 thousand tonnes, respectively (Table 1). With the such abundant crops and yield, agricultural by-products are available feed resources for cattle production. Currently, rice straw is usually burned on the field and very few households bring rice straw to reserve for cattle in the winter. Corn cobs and stalks are rarely used as feed for cattle, but mostly burned after harvesting and seed extraction. Despite their abundance, these feed resources have not been fully and optimally utilized as beef cattle rations. Hence, there is a need for more research to enable optimal utilisation of the locally available feed resources for production of quality beef, especially in the winter.

Table 1. Area and production of main crops in Vietnam

	Year	**2014**	**2015**	**2016**	**2017**	**2018**
Paddy	Area (1000 ha)	7.816,2	7.828,0	7.737,1	7.705,2	7.570,4
	Yield (1000 tons)	44.974,6	45.091,0	43.165,1	42.738,9	43.979,2
Maize	Area (1000 ha)	1.179,0	1.178,9	1.152,7	1.099,5	1.039,0
	Yield (1000 tons)	5.202,3	5.287,2	5.246,5	5.109,6	4.905,9
Cassava	Area (1000 ha)	552,8	567,9	569,0	532,6	515,3
	Yield (1000 tons)	10.209,9	10.740,2	10.909,9	10.267,7	9.960,3
Sweet potato	Area (1000 ha)	130,1	127,6	120,3	121,8	117,9
	Yield (1000 tons)	1.401,3	1.335,9	1.269,3	1.352,8	1.368,6

Source: GSO, 2014-2018

An investigation in Northern mountainous regions by Tuan (2015) showed that ruminants depend on year-round grazing on natural pastures or the animals are fed with cut grass and crop residues. Most of these areas face seasonal dry periods (from December to March) in which the availability of pasture decreases and also its quality by a reduction in the content of digestible energy and nitrogen (Sarnklong et al., 2010). According to the relative assessment of livestock farmers, natural feed sources in the year can be divided into two periods: 1) The first period from April to mid of November is a favorable period for beef production in the year, in which from May to October the source of natural forage is not only enough but also abundant demand of the cattle herd; 2) The second period from mid-November to March is a period of green forage lacking, meeting only 12 to 40% of cattle demand. During this time, farmers have to use the agricultural by-products to feed the cattle.

With the high average amount of agricultural by-products in each household (5,431 kg/household) (Table 2) in Northern mountainous regions, this is the potential that cattle producers can exploit to overcome the shortage of natural feed sources and expand the scale of beef production.

Table 2. The amount of agricultural by-products in household in Northern mountainous regions

Type of agricultural by-product	**Dry matter of agricultural by-products (kg/household)**
Rice straw	2,725
Corn stalks	2,317
Corn cob	324
Cassava foliage	66
Total	**5,431**

Source: Tuan (2015)

The chemical characteristics of agricultural by-products

Corn stalks and cobs

The chemical compositions and nutritive value of corn stalks are shown in the Table 3. Crude protein and crude fiber contents of corn stalks were in range 6.11-11.44% and 9.63-35.00%, respectively. In general, the chemical compositions and nutritional value of corn stalks is highly variable, depending on growth stage, harvesting time and processing (Ngoan et al., 2006). According to Ngoan et al. (2006), crude protein content of young corn stalks is higher than that of grass. Corn stalks after grain harvest are so hard and dry, therefore it is necessary to be shorten before drying or ensiling.

Ensiling: Corn stalks can be successfully ensiled after grain harvest if the stalks contain sufficient moisture (>45%) to ensile (Hoffman et al., 2016). The utility of ensiling corn stalks is often highly dependent on fall weather and drying conditions. If attainable, ensiled corn stalks make an excellent beef forage. Corn stalks should be finely chopped prior to ensiling to aid packing, fermentation and to minimize sorting when feeding.

Treatment with urea: Urea is typically applied to wet corn stalks (50% moisture) and ensiled (Hoffman et al., 2016). A 3% (dry matter basis) treatment rate is common in literature, but a number of commercial molasses-urea mixtures are also available. Urea treated corn stalks must be stored in a manner to exclude oxygen and stored for at least 21 days before feeding. Overall, urea treatment does not improve the digestibility to the extent of the other treatment methods, but urea is safer to handle and more accessible than the alternatives.

Table 3. Chemical compositions and nutritive value of corn stalks (% on dry matter basis)

Feedstuff	DM	CP	EE	CF	ADF	NDF	ASH	ME (Kcal/kg DM)	Authors
Corn stalks after early rippen harvest	37.4	9.36	5.62	9.63			2.14	2837	NIAS, 2001
Corn stalks after grain harvest	61.6	7.63	1.95	31.5			7.14	1958	
Corn stalks after early rippen harvest	29.87	7.53	-	28.66			11.58	-	
Young corn stalk silage	22.99	6.11	3.48	28.93			12.48	2023	
Corn stalks at lade stage	32.2	7.45	1.24	15.84	-	-	-	-	Ngoan et al. (2006)
Corn stalks after early rippen harvest	33.4	7.18	2.4	18.26	-	-	-	-	
Corn stalks after grain harvest	42.2	7.35	2.61	18.48	-	-	-	-	
Dried corn stalks	-	6.3	1.3	35			7.4		
Corn stalk silage		6.5	3.3	31.9			5.0		

Feedstuff	DM	CP	EE	CF	ADF	NDF	ASH	ME (Kcal/kg DM)	Authors
Whole-crop corn silage	32.47	8.02	2.4	-	29.52	50.0	6.87		Roman et al. (2011)
Corn stalks after grain harvest	54.2	11.44	3.32	-	48.2	65.6	13.2		Hoffman et al. (2016)

Corn cob accounts for about 20% of the whole roasted corn. This is a low nutritive value compared to dry grass and unappetizing. Corn cob with high humidity is easy to get mold after a few days. However, corn cobs can be combined with other feeds to fatten beef cattle (Ngoan et al., 2006).

The dry matter (DM), crude protein (CP), ash, neutral detergent fiber (NDF) and acid detergent fiber (ADF) of maize cobs are shown in Table 4. The mean CP (31 g/kg DM), ash (48.3 g/kg DM), and ether extract (6.4 g/kg DM) of maize cobs (Table 4) are quite low compared to a conventional fiber source such as rice bran (CP 116 g/kg DM, ash 120 g/kg DM, ether extract 118 g/kg DM) (Ngoc et al., 2012). The mean fiber components (NDF 816.4 g/kg DM and ADF 503 g/kg DM) are higher than in rice bran (NDF 440 g/kg DM and ADF 152 g/kg DM) (Ngoc et al., 2012 and PhuThinh Co., 2012). The composition of maize cobs is affected by stage of maturity, cultivar, climate, soils and production methods (Szyszkowska et al., 2007). Mature cobs have higher NDF, ADF, DM and lower CP and starch than less mature cobs. Szyszkowska et al. (2007) reported that DM content in cobs was positively correlated with the content of starch, and negatively with the content of NDF and ADF fractions. The cultivars tested in the afore-mentioned study did not differ in ADF, NDF, and starch content in cobs. The mineral composition depended on the cultivar, effective temperature sum and the farm type.

Table 4. Chemical compositions and nutritive value of corn cobs (% on dry matter basis)

Nutrient (g/kg DM)	A	B	C	E	
Dry matter	908.3	885.2	900	-	-
Crude protein	38.9	32.6	25	37.5	21
Ether extract	5.7	-	6	6	8
Ash	76.7	72.6	26	38	28
Crude fiber	286.9	-	324	387	365
Nitrogen free extract	-	-	529	533	578
Neutral detergent fiber	706.3	929.8	-	813	-
Acid detergent fiber	515.8	573.2	-	421	-
References	Akinfemi (2010)	Kanengoni et al. (2004), Chimonyo et al. (2001)	Bredon et al. (1987)	Stanogias and Pearce (1985)	Ngoan et al. (2006)

Rice straw

Rice-straw, the most important crop residue feed for ruminants, is readily available throughout the country. Rice straw is low in energy, protein and vitamins but contains a high carbohydrate content which can be degraded by rumen microbes into volatile fatty acids - an important energy source for ruminants (Wanapat, 1999). The chemical compositions of rice straw vary between varieties and growing seasons, with higher nitrogen and cellulose contents in early season rice compared to others (Shen et al., 1998). The chemical compositions of rice straw, cited by different researchers, are illustrated in Table 5. Rice straw contains 31.96-60% cellulose, 13.0-32.24% hemicellulose and 4.63-13.0% lignin with low crude protein and high quantities of silica which hinder the nutrient availability to rumen microbes and eventually limits the necessary nutrient uptake for a satisfactory performance of the animals (Sheikh et al., 2018).

Table 5. Chemical composition of rice straw

Criteria	**Sheikh et al. (2018)**	**Sarnklong et al. (2010)**	**NIAS (2001)**
DM	88.00-96.87	96.30	86.08
CP	2.00-6.50	6,0	5.66
CF	30.00-40.00	-	34.84
ADF	49.00-73.01	41.59	-
NDF	39.83-85.00	73.01	-
NFE	40.00-46.00	-	43.81
Hemi-cellulose	13.00-32.24	31.42	-
Cellulose	31.96-60.00	33.35	-
Ash	11.00-16.00	12.1	14.01
AIA	3.00-5.00	3.40	-
ADL	4.63-13.00	4.84	-
Si	4.25-13.00	4.25	-

Basically, the key to improving the use of crop residues for ruminants is to overcome their inherent barriers to rumen microbial fermentation. In the case of rice straw, the important factors that restrict bacterial degradation in the rumen are its high levels of lignification and silicification, and its low contents of nitrogen, vitamins and minerals. To improve the feeding value of rice straw, the straw can be treated with different means and methods and other required nutrients can be supplied to the ration of the animal strategies to improve the utilization of rice straw are summarized in Figure (after Ibrahim, 1983)

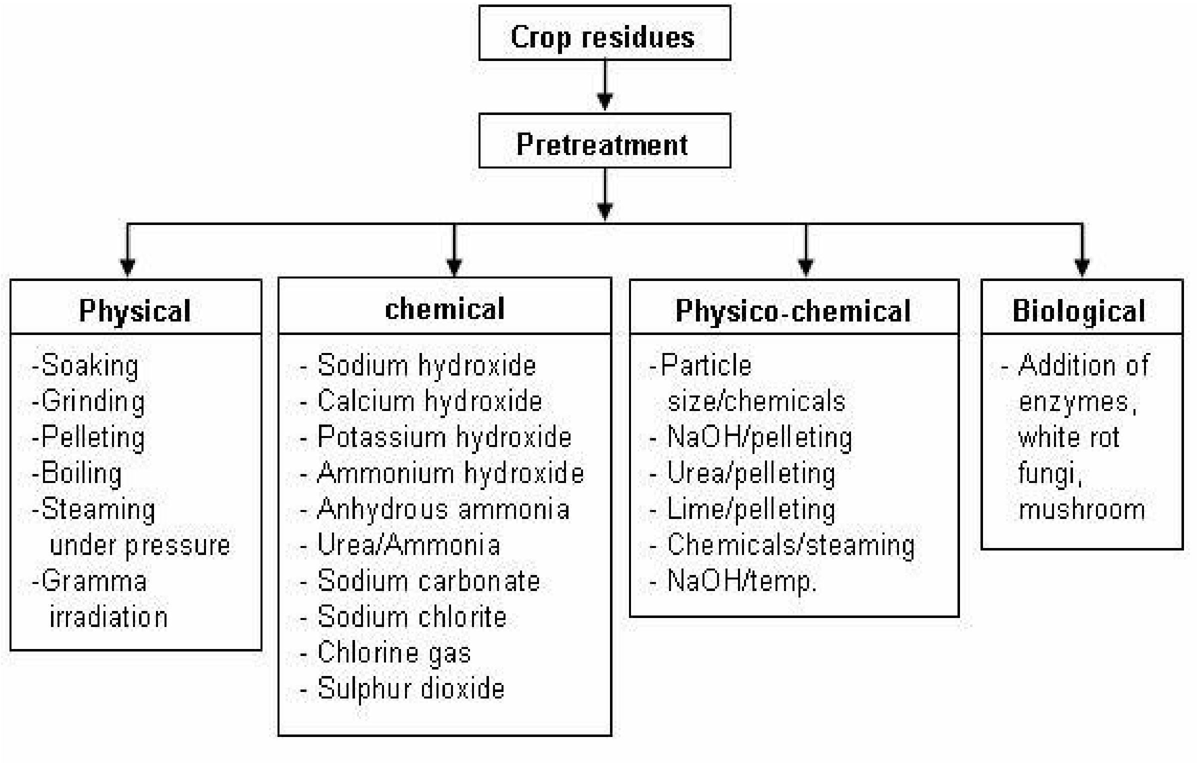

Figure 1. Method available for treating crop residues (Ibrahim, 1983)

Urea treatment: Rice straw can also be treated with urea, which releases ammonia after dissolving in water. For practical use by farmers, urea is safer than using anhydrous or aqueous ammonia and also provides a source of nitrogen (crude protein) in which straw is deficient (Schiere and Ibrahim, 1989). Since urea is a solid chemical, it is also easy to handle and transport (Sundstøl and Coxworth, 1984) and urea can be obtained easily in many developing countries. In addition, urea is considerably cheaper than NaOH or NH_3. Vadiveloo (2003) reported that rice varieties with a low degradability responded better to urea treatments than higher quality straw, increasing the in vitro dry matter degradability from 45 to 55-62%. Urea treatment may therefore be most suitable for small-scale farmers to improve the quality of straws, particularly varieties showing a low degradability. Besides, rice straw can be treated urea with or without additional supplementation (Shen et al., 1998; Vadiveloo, 2003; Prasad et al., 1998; Vu et al., 1999; Akter et al., 2004). Pradhan et al. (1997) showed that addition of $Ca(OH)_2$ to urea improved the IVDMD. Sirohi and Rai (1995) demonstrated that a combination of 3% urea plus 4% lime at 50% moisture for 3 weeks incubation time was the most effective treatment for improving degradability of rice straw. Using urea is regarded as a practical and available method in livestock production, especially in developing countries, as it is relatively cheap, adds nitrogen to the ration and is relatively safe to work with.

The chemical compositions of urea-treated rice straw summarized from some researches are shown in Table 6.

Table 6. Chemical composition of urea-treated rice straw (% on DM basis)

Criteria	4% urea-treated rice straw	4% urea-treated rice straw after 0 ensiled-day	4% urea-treated rice straw after 21 ensiled-days	Untreated rice straw	3% urea-treated rice straw	Urea-calcium hydroxide treated rice straw (2-2%)
DM	61.49	83.81	82.02	87.8	50.5	86.2
CP	11.00	6.12	6.15	2.7	6.0	5.5
EE	1.72		-		-	
CF	33.81	34.08	33.35		-	
NDF	74.52	-	-	84.8	74.5	76.5
ADF	47.54	-	-	63.7	54.1	56.2
Ash	13.89	14.43	14.85	11.2	11.9	15.8
Authors	Tuan, 2015	Truong La, 2012		Wanapat et al., 2013		

Cassava foliage

Cassava foliage includes leaves (45%), petiole (25%) and tenderstem (30%) (Ravindran, 1993). Cassava foliage is recognised as a locally available animal feed resource with a high edible biomass yield (Hue, 2012; Khang et al., 2005). The CP concentration of cassava foliage is in the range from 17.69-22.62% (Table 7). Hue (2012) and Khang et al. (2005) reported that the DM, CP, NDF, ADF and content of total tannins in cassava foliage were affected by harvesting interval. The longer the cutting interval, the higher the DM, NDF, ADF and total tannin contents in cassava foliage. In contrast, CP and HCN content were lower at later harvesting time.

Many studies have focused on cassava foliage as a feed for animals, especially for ruminants. Fresh cassava foliage or cassava hay has been fed to cattle, both beef and dairy, with good results (Thang et al., 2010; Wanapat, 2009; Wanapat et al., 1997). However, a limitation when feeding cassava foliage is the content of cyanogenic glucosides, mainly linamarin and lotaustralin (Alan and John, 1993). Hydrolysis of these cyanogenic glucosides liberates hydrogen cyanide (HCN) (Poulton, 1988) and causes toxicity symptoms in animals when they exceed the tolerated dose. Acute HCN toxicity symptoms include saliva excretion, vomiting, excitement, staggering, paralysis, convulsions, coma and death. The signs of toxicity may occur within seconds or minutes following consumption of pure HCN, but there may be no symptoms of cyanide poisoning when cyanogenic plants are eaten slowly or over a period of time (Burritt and Provenza, 2000). Thus, understanding the dietary effects of cassava foliage so that animals could be fed the optimal amount to give the best performance and to minimise the incidence of HCN toxicity would be beneficial for cattle production. Wilting, drying or ensiling cassava foliage would markedly reduce their HCN content (Hue, 2012), so cassava foliage should be processed before feeding cattle.

According to Hoste et al. (2006), tannins are secondary compounds present in plants and comprise polyphenols of great diversity. The physical and chemical properties of tannins vary with different plants and in different plant parts and seasons (Waghorn et al., 1990). Based on their structure, Haslam (1989) categorised tannins into two major groups, hydrolysable tannins and condensed tannins. Hydrolysable tannins consist of gallic and ellagic acid esters of sugars, which are more soluble in the water and more susceptible to enzymatic and non-enzymatic hydrolysis (Haslam, 1989). When hydrolysable tannins are consumed by ruminants, they can be degraded into gallic and ellagic acid, and absorbed in the digestive tract. Hydrolysable tannins are thus considered to have a negative physiological effect on ruminants, almost comparable to a toxic effect (Hoste et al., 2006). Condensed tannins are polyphenols of higher molecular weight and consist of oligomers or polymers of catechin, which mainly produce cyanidin and delphinidin when depolymerised (Waterman, 1999). According to Hoste et al. (2006), only a small amount of condensed tannins is absorbed in the digestive tract of ruminants, because they are not susceptible to hydrolysis. Condensed tannins bind strongly to protein and this reactivity is pH dependent (Reed, 1995). The condensed tannin-protein complexes are formed at pH 3.5-7.5 and are dissociated at pH <3.5 and the protein is thus released (Jones and Mangan, 1977). The major beneficial effect of tannins is the protection of plant protein from digestion in the rumen, making the protein available for digestion and utilisation in the lower gut (Waghorn et al., 1990). However, higher tannin levels (above 50 g/kg DM) in plant material can become an anti-nutritional factor and can result in reduced feed intake and digestibility in animals (Barry and McNabb, 1999).

Table 7. Proximate composition of whole plant cassava, cassava leaves and tender stems (DM basis, except for DM which is on air-dry basis)

	Cassava foliage	**Cassava leaves**	**Cassava tender stems**	**Cassava foliage**
Dry matter	19.1-29.2	92.7	93.8	16.35-29.51
Crude protein	18.5-20.8	18.0	10.7	17.69-22.62
Crude fibre	-	14.1	27.9	-
NDF	36.4-43.2	-	-	34.19-41.22
ADF	20.7-31.6	-	-	22.57-30.23
Ether extract	-	9.4	3.64	6.96-7.89
Ash	-	7.9	10.0	4.98-5.29
NFE	-	43.3	41.6	-
HCN* (mg/kg)	307-730	-	-	835-958
Total tannin (mg/kg)	2.74-4.36	-	-	3.14-4.32
Authors	Modified from Hue (2012)	Akinfala et al., 2002		Modified from Khang et al., 2005

*Note: *mg/kg fresh weight*

The utilization of the integration of crop by-products and forages for beef cattle production

In crop-livestock systems, large amounts of cereal crop residues (straw, stubble) and food crop by-products with little alternative value (rejected fruit and vegetables, oilseed meals and cereal grains) are often available on a seasonal basis. Although the nutritional quality of agricultural by-products can be low, their large quantity constitutes a very important potential for ruminant development in Vietnam (Ly, 1995). To feed requirement in the winter or dry season, agricultural by-products can be used to replace green grass in the cattle diet. There have been many researches on using agricultural by-products for feeding cattle, such as rice straw (Trach et al., 1999), corn stalks after grain harvest (Tuan et al., 1999, Cuong et al., 2005), groundnut vines (Tao, 1996) or combining different fibre sources in the cattle diet from corn stalks, rice straw, corn cobs (Cuong et al., 2007).

Rice straw is usually dried in the field after harvesting, piled up and stored in the backyard over a long period. Cattle are often fed with rice straw at night or during the cold, rainy weather when grazing is not possible (Ly, 1995). Recently, many researches have been investigated urea-treated rice straw as feed for cattle. Urea-treated rice straw (straw ensiling) is found to improve the digestibility (Jayasuriya and Perera, 1982) and availability of cellulose and hemicellulose (Silva and Orskov, 1988) as well as improve nitrogen content (Saadullah et al., 1981). Urea feeding as a urea molasses block along with rice straw to cattle, sheep and buffalo has been found to give a satisfactory improvement of straw digestibility (Leng, 1984; Tiwari et al., 1990). However, this method is not yet easily adopted by the village level farmers because this method is tedious and involves much labor and time. As a result, development of easy technology for incorporation of urea into straw based ration, which can be acceptable to the village farmers, is of paramount importance.

A study done by Tham et al. (2015) was carried out on growing yellow cattle in Dien Bien and Son La from 1-4/2015. The results indicated that the amount of green grass that cattle earned on the pasture was only about 50% of their eating ability. Therefore, cattle in control and treatment groups could eat more 1.47% DM/100kg body weight from untreated rice straw and 2.27% DM/100kg body weight from 3% urea-treated rice straw and cassava root silage, respectively. The ADG in treatment group was improved about 144% compared to control group. Another research in Dien Bien done by Tuan (2015) pointed that the average daily gain was different among treatments, with the lowest value for free grazing cattle group (0.125 kg/head/day), followed by free grazing cattle group added urea-treated rice straw (0.271 kg/head/day) and the highest value for free grazing cattle group added urea-treated rice straw and concentrate (0.504 kg/head/day). The author also indicated that due to poor quality of natural pasture from August to October in Dien Bien, the growing cattle with the body weight of 176 - 178 kg can get an average of 3.3 kg DM/head/day and 27.62 MJ ME/head/day, if only grazing. This amount of feed and ME was sufficient for maintaining body weight and very low weight gain of approximately 0.125 kg/head/day.

Studies carried out by Sharma and Singh (1988) on the feeding of urea treated straw indicated that without concentrate or green supplementation treated straw can support a growth rate of 7-318 g/day depending on the type of animal and level of intake of treated straw and types of supplement. Ahmed et al. (2002) indicated that body weight gain of the growing bull calves on 6% soybean meal along with urea-treated rice straw was significantly higher than animals fed 4% urea treated rice straw (A); no significant difference was observed between diets 4%

urea+4% soybean treated rice straw (B) and 4% urea+6% soybean treated rice straw (C). Significantly higher body weight gains of the animals of groups B and C in comparison to the animals of group A may be due to the fact that addition of 4 and 6% soybean meal with urea at the time of treatment helps to supply more protein to the animals of these groups and also resulted in higher digestibility of CP, CF and OM.

Table 8. Urea-treated rice straw efficacy: effects on growth performance in cattle

Control diet	Treatment diet	Response	Reference
Natural grass from free grazing +Untreated rice straw	Natural grass from free grazing +Urea-treated rice straw + cassava root silage	ADG and feed intake were improved in treatment group	Tham et al., 2015
Natural grass from free grazing	- Natural grass from free grazing +Urea-treated rice straw - Natural grass from free grazing +Urea-treated rice straw + concentrate	Better ADG in treatment diet	Tuan, 2015
4% urea treated rice straw	- 4% urea+4% soybean treated rice straw - 4% urea+6% soybean treated rice straw	Higher total DM intake (56 days) and total live weight gain in the treatment diets	Ahmed et al., 2002

Maize stems are also available in large quantities after harvesting. However, due to their harvesting time is short and storage that maintains quality is difficult, only little amounts are used as animal feed in Vietnam (Hai, 2015). Hung and Binh (2004) studied the use of post-harvest corn stalks for 18-month-old Sind crossbred cattle after free grazing during the dry season in Daklak province. The results showed that average daily gain was higher for cattle supplemented 4% urea-treated corn stalks with concentrate feed for 90 days (784.2 g/head/day) than for cattle supplemented concentrate feed (561.3 g/head/day) or cattle just only tended grazing (320.8 g/head/day).

Truong La (2012) reported that in the dry season in Daklak province, the average daily gain of the cattle group fed 50% corn stalk silage was 538 g/head/day, similar to the cattle group fed 100% fresh grass (553 g/head/day). However, the economic efficiency was higher for cattle fed 50% corn stalk silage than for those fed 100% fresh grass. Another study Daklak province by Truong La (2011) showed that average daily gain of Sind crossbred cattle was significantly different among the diets containing different corn cobs levels, with the highest value for the diet containing 10% corn cobs (0.745 kg/head/day), followed by the diet containing 20% corn cobs (0.689 kg/head/day) and the lowest for the diet containing 30% corn cobs (0.633 kg/head/day). Economic benefit was similar among the diets containing different corn cobs level. Weight gain of fattening cattle decreases with the increase of corn cob in the diet. Thus, different corn cobs level in the diet affect the weight gain of experimental animals. Corn cobs are fibre-rich by-products, so as corn cobs level in the diet increases, the dietary fibre content increases as a consequence of the increased dietary fibre content reduce the ability to increase the weight of the fattening. Cuong et al. (2007) found that diets containing 27% rice straw or diet combined with 14% rice straw and 13% dry corn cobs were the best source of dietary fibre for fattened cattle.

In Vietnam, cassava is usually planted by the farmers with the main purpose of root harvesting and the stems and leaves are left in the field. It has been shown that these residues can be a valuable source of protein for feeding to many kinds of animals (Preston, 2001). When farmers harvest cassava root, the stems and leaves are still a good quality protein feed for cattle particularly in the dry season. This situation can give an opportunity for farmers to get more benefit by collecting the cassava leaves for cattle feeding. Therefore, it is important to promote ways of maximizing the use of this valuable crop. An experiment with local beef cattle with the aim of evaluating the effects of supplementation difference levels of fresh (FCF), ensiled (ECF) or pelleted cassava foliage (PCF) on feed intake, growth performance in diets based on urea treated fresh rice straw (Khang and Wiktorsson, 2006). The authors concluded that FCF, with its high HCN and condensed tannin content, was slightly unpalatable (6% and 20% residue in ECF and FCF, respectively), and had an adverse effect on growth rate, while ECF and PCF supplementation resulted in improved growth rate without adverse effects on feed intake when fed to growing heifers. Tuan (2015) reported that in Son La province the use of cassava flour and cassava leaf meal in the yellow cattle diet increased weight gain and feed efficiency. Cattle fed diets supplemented with cassava flour and cassava leaf meal gave an average daily gain of 479 g/head/day and 8.93 kg DM/1kg weight gain, while cattle fed without cassava flour and cassava leaf meal gave an average daily gain of 281 g/head/day and feed consumption of 13.05 kg DM/1 kg weight gain.

Table 9. The value of cassava foliage as nitrogen-roughage source for growing cattle

Basal diet a	Cassava foliage (%)	Response	Reference
Sugarcane + urea	0, 15, 30, 45	Low response and not related to level of supplementation	Meyrelles et al. (1977a)
Sugarcane	0, 15, 30, 45	Low growth rate, better on cassava foliage	Meyrelles et al. (1977b)
Sugarcane + urea	20, 40	Low growth rate (0.14-0.24 kg/day), better with cassava foliage +urea	Meyrelles et al. (1977c)
Molasses + urea	2, 3, 4.5 (fresh)	Linear increase in growth rate, 0.37, 0.47, 0.91 kg/day	Fernandez and Preston (1978)
Molasses + urea + soybean meal	4.5 (fresh)	High intake (6.1 kg/day), high growth rate (0.9 kg/ day) on cassava foliage	Ffloukes and Preston (1978)
Rice straw	0, 0.25, 0.5, 0.75, 1 (of live weight, DM basis)	Linear increase in growth rate, 201, 266, 282, 278, 402	Sath et al. (2008)

Early work with cassava foliage supplementation in the growing cattle showed that better growth rate was given for the diet based on sugarcane or sugarcane + urea with cassava foliage (Meyrelles et al., 1977a, b). Cassava foliage as the sole source of supplementary protein and roughage in diets for fattening cattle based on liquid molasses-urea was confirmed by studies of Ffoulkes and Preston (1978) and Fernandez and Preston (1978). When used as a supplement to untreated rice straw the growth rates in local "yellow" cattle were increased threefold by supplementing them with fresh cassava foliage (Seng Mom et al., 2001). Similarly, Sath et al. (2008) concluded that increasing levels of sun dried cassava foliage led to significant increases in total dry matter intake and daily weight gain of cattle fed untreated rice straw and this foliage appears to be a good source of bypass protein source for cattle.

When low quality grasses and crop residues are fed to cattle, concentrates are essential for compensating nutritional deficiencies and ensuring balanced diets (Hai, 2015). Rice bran, maize, cassava powder, fish meal, and urea are the most common concentrate feed sources (Dung et al., 2013). However, due to the expensiveness of concentrate feeds in tropical developing countries, their use must be efficient in order to achieve maximum profit (Kokkonen et al., 2004). Concentrates have a significant effect on cattle feed intake. High concentrate levels in the diet typically increase DM intake (Haddad, 2005; Salim et al., 2002; Tufarelli et al., 2009), weight gain and improve feed efficiency, carcass characteristics, and reduce feed costs (Haddad, 2005). Several researches in Vietnam (Ba et al., 2008 a,b and 2010; Trung et al., 2014; Dung et al., 2013) have studied on concentrate supplement for growing and fattening cattle. Ba et al. (2008b, 2010) showed that live weight gain increased linearly with increased consumption of concentrate supplement in the fattening yellow cattle diet and increasing the amount of concentrate in the diet also significantly reduced feed costs. Supplementation of cassava powder in the diets based on untreated or urea-treated rice straw improved feed intake and live weight gain of growing Sind crossbred cattle (Ba et al., 2008a; Trung et al., 2014).

However, ruminant nutrition studies have concentrated on very little on beef cows (Hai, 2015). Hai (2015) suggested that the improved diet (15.6% CP) is suitable as a supplementary source of nutrients for crossbred beef cows in South Central Coastal Vietnam. Supplementation with an improved diet pre- or post- partum had positive effects on cow weight, body condition score, and fertility, as well as the weight and size of calves at parturition compared with the control diet (9.8%). In addition, supplementation with an improved diet post-partum can help to reduce the calving to conception interval by 60-70 days compared with cows on the control diet.

The appropriate age and time for fattening cattle

Feeding management of beef cattle can be divided into the three phases of rearing, growing and finishing. Each phase requires different ration specifications, according to cattle type and target growth rates. The length of each phase of the production cycle varies with breed, frame size and target market. Native breeds or small framed cattle usually require a longer growing period based on forages, but shorter finishing period than larger continental cattle (Vikers and Stewart, 2016). The latter are most efficient on rations containing high quality feeds and forage that facilitate fast growth rates. Similarly, bulls are better suited to systems based on energy dense diets, which exploit their potential for fast, lean growth. These systems can effectively miss out the growing phase and the animal is transferred directly from its rearing to its finishing phase. Having an understanding of the type of cattle to be fed and the target market, will enable producers to plan targets for the various stages of the production system.

Cai (2006) conducted a study on six month-fattening time of pure white Brahman cattle at 18-month-old with average body weight of 259 kg. The results indicated that average weight gain during the finishing period was 955 g/head/day. However, average daily gain in the first two months was very high (over 1,500 g/head/day), whereas it decreased significantly in the last 3 months (from 823 g/head/day in the 4th month to 600g/head/day in the 6th month). The author concluded that the appropriate fattening time should be lasted 3 months for cattle at 18 months of age. This result was also confirmed by Dat et al. (2013) and Van (2014). Cai et al. (2006) showed that at the finishing period average weight gain of Sind crossbred (833 g/head/day) was lower than F1 (Brahman x Sind crossbred) (1,104 g/head/day) and F1 (Charolais x Sind crossbred) (1,148 g/head/day).

Trach and Nhac (2008) studied on the effect of age and concentrate level in diets on growth rate and economic efficiency of fattening beef cattle. The authors concluded that average weight gain was higher for finishing cattle group than for growing cattle group (548 vs. 475 g/head/day). Increasing concentrate used resulted in increasing average weight gain. However, when using 3.5 kg concentrate/head/day, the economic efficiency was not high.

According to Vikers and Stewart (2016), a semi-intensive beef system usually involves a period at grass, a housed winter period and a finishing period when the cattle are also often housed. Farms that have a source of cereals or by-products and straw are more likely to operate an intensive system, while farms in grassland areas are likely to operate semi-intensive or extensive systems. It is important to recognise that variable and fixed costs per head are likely to increase with the number of days the cattle are on the farm and that feed conversion efficiency reduces as cattle grow older and heavier.

Opportunities for development through interventions on farm

There are many opportunities for smallholder farmers in Vietnam to meet the increased demand for beef to generate improved incomes. However, inadequate grazing land, unstable supply of traditional feed resources, increasing price of purchased feed and the unavailability of labour are major challenges that inhibit the development of beef cattle production system in mountainous areas of Vietnam. Therefore, it is important to understand the current animal, feed, shelter and health management practices in order to chart innovative directions and strategies for further beef cattle research and development in mountainous areas of Vietnam. Research priorities on beef cattle production should be concerned on feeding and management of finishing (fattening) cattle, cow-calf production, weaned calf and pregnant cows to shift from extensive and more intensive systems.

REFERENCES

Ahmed, S., Khan, M. J., Shahjalal, M. and Islam, K. M. S. 2002. Effects of Feeding Urea and Soybean Meal-Treated Rice Straw on Digestibility of Feed Nutrients and Growth Performance of Bull Calves. Asian-Australian Journal of Animal Science Vol 15, No. 4, pp. 522-527

Akinfemi, A. 2010. Nutritive value and *in vitro* gas production of fungal treated maize cobs. African Journal of Food Agriculture Nutrition Development 10, pp. 2943-2955.

Akinfala, E. O., Aderibigbe, A. O. and Matanmi, O. 2002. Evaluation of the nutritive value of whole cassava plant as replacement for maize in the starter diets for broiler chicken. Livestock Research for Rural Development 14 (6) 2002. http://www.lrrd.org/lrrd14/6/akin146.htm

Akter, Y., Akbar, M. A., Shahjalal, M. and Ahmed, T. U. 2004. Effect of urea molasses multi-nutrient blocks supplementation of dairy cows fed rice straw and green grasses on milk yield, composition, live weight gain of cows and calves and feed intake. Pakistan Journal of Biology Science 7(9), pp. 1523-1525.

Alan, J. D. and John, A. M. 1993. Effect of oral administration of brassica secondary metabolites allyl cyanide, allyl isothocyanate and dimethyl disulphide, on the voluntary food intake and metabolism of sheep. British Journal of Nutrition 70, pp. 631-645.

Ba, N. X., Dung, D. V., Mui, N. T., Van, N. H., Son, P. H., Mai, H. T., Hai, T. T., Smith, R., Parsons, D. and Corfield, J. 2015. Cow-calf production systems in households in South Central Coastal Vietnam. Journal of Agriculture and Rural Development 21, pp. 109-117.

Ba, N. X., Dung, D. V., Phung, L.D., Ngoan, L. D. and Cuong, V. C. 2010. Effect of concentrate feed intake on growth performance and meat quality of yellow cattle in Vietnam. Vietnamese Journal of Animal Science Technology 27, pp. 37-44

Ba, N. X., Van, N. H., Ngoan, L. D., Leddin, C. L. and Doyle, P. T. 2008a. Amount of Cassava Powder Fed as a Supplement Affects Feed Intake and Live Weight Gain in Laisind Cattle in Vietnam. Asian-Australian Journal of Animal Science Vol. 21 No. 8, pp. 1143-1150.

Ba, N. X., Van, N. H., Ngoan, L. D., Leddin, C. L. and Doyle, P. T. 2008b. Effects of amount of concentrate supplement on forage intake, diet digestibility and live weight gain in Yellow cattle in Vietnam. Asian-Australian Journal of Animal Science Vol.21, No 12, pp. 1736 - 1744.

Barry, T. and McNabb, W. 1999. The implications of condensed tannins on the nutritive value of temperate forages fed to ruminants. British Journal of Nutrition 81(04), pp. 263-272.

Bredon, R. M., Stewart, P. G. and Dugmore, T. J. 1987. A Manual on the Nutritive Value and Chemical Composition of Commonly Used South African Farm Feeds. Department of Agriculture and Water Supply, Natal Region, South Africa.

Burritt, E. and Provenza, F. 2000. Role of toxins in intake of varied diets by sheep. Journal of Chemical Ecology 26(8), pp. 1991-2005.

Cai, D. V. 2006. The results of pure Drought Master beef cattle imported in some southern provinces. Breeding Journal of Animal Science No. 1, pp. 9-13.

Cai, D. V., Truong, H. V. and Tuan, D. T. 2006. The results of adaptation and pure white Brahman cattle imported from Cuba and raised in Binh Dinh. Vietnamese Journal of Animal Science Technology No. 10, pp. 7-10.

Chimonyo, M., Kanengoni, A. T. and Dzama, K. 2001. Influence of maize cob inclusion level in pig diets on growth performance and carcass traits of Mukota × Large White F1 crossbred male pigs. Asian Austra. J. Anim. Sci. 14, pp. 1724-1727.

Cuong, V. C., Cuong, P. K., Hue, P. T. and Hung, P. M. 2007. Effects of different fiber sources in fattening diets on weight gain and feed efficiency of Sind crossbreds in Dak Lak. J. Anim. Sci. Technol. No. 4-2007

Dat, N. Q., Binh, N. T., and Tuyen, D. V. 2013. Growth performance and meat production Sind crossbred, Brahman and Droughtmaste purebred cattle raised in Ho Chi Minh City. Outstanding research results in the field of Agriculture and Rural Development in the early 21st century. Ministry of Agriculture and Rural Development. pp. 400-411.

Dung, D. V., Ba, N. X., Van, N. H., Cuong, V. C. and Yao, W. 2013. Practice on improving fattening local cattle production in Vietnam by increasing crude protein level in concentrate and concentrate level. Tropical Animal Health Production vol. 45, no. 7, pp. 1619-1626.

Haddad, S. G. 2005. Effect of dietary forage:concentrate ratio on growth performance and carcass characteristics of growing Baladi kids. Small Ruminant Research, vol. 57, pp. 43-49.

Hai, T. T. 2015. Strategic nutritional enhancement of cow-calf performance in South Central Coastal Vietnam. Master thesis. School of Land and Food, University of Tasmania.

Haslam, E. 1989. Plant Polyphenols - Vegetable Tannins Revisited. [online]. Cambridge University Press, Cambridge, U.K.

Hoste, H., Jackson, F., Athanasiadou, S., Thamsborg, S. M. and Hoskin, S. O. 2006. The effects of tannin-rich plants on parasitic nematodes in ruminants. Trends in Parasitology 22(6), pp. 253-261.

Hung, N. T. and Binh, D. V. 2003. Using corn stalks after grain harvesting as feed foe fattening Sind crossbred in drought season. http://www.hua.edu.vn:85/cnts/index.php?option=com_content&task=view&id=268&Itemid=218

Hue, K. T. 2012. Feeding cassava foliage to sheep: Nutrient properties and hydrogen cyanide toxicity. Doctoral Thesis, Swedish University of Agricultural Sciences.

Ibrahim, M. N. M. 1983. Physical, chemical, physico-chemical and biological treatments of crop residues. In: The Utilization of Fibrous Agricultural Residues (Ed. G. R. Pearce). Australian Development Assistance Bureau, Research for Development Seminar three, Los Banos, Philippines, 18-23 May 1981. Australian Government Publishing Service, Canberra, Australia. pp. 53-68.

Jayasuriya, M. C. N. and Prera, H. G. D. 1982. Urea-ammonia treatment of rice straw to improve the nutritive value for ruminants. Agricultural Wastes 4 (2), pp. 143-150

Jones, W. T. and Mangan, J. L. 1977. Complexes of the condensed tannins of sainfoin (Onobrychisviciifolia Scop.) with fraction 1 leaf protein and with submaxillary mucoprotein, and their reversal by polyethylene glycol and pH. Journal of the Science of Food and Agriculture 28(2), pp. 126-136.

Juliano Roman, Clóves Cabreira Jobim, Flávio Dutra de Resende, Gustavo Rezende Siqueira, Marcelo Henrique de Faria and Renato Alves de Oliveira Neto. 2011. Performance of finishing beef cattle fed different diets containing whole-crop maize silage or sugarcane silage. RevistaBrasileira de Zootecnia. v.40, n.3, pp. 682-689.

Kanengoni, A. T., Dzama, K., Chimonyo, M., Kusina, J. and Maswaure, S. M. 2004. Growth performance and carcass traits of Large White, Mukota and Large White × Mukota F1 crosses given graded levels of maize cob meal. Animal Science 78, pp. 61-66.

Keo Sath, Khieu Borin and Preston, T. R 2008. Effect of levels of sun-dried cassava foliage on growth performance of cattle fed rice straw. Livestock Research for Rural Development 20 (supplement) 2008. http://www.lrrd.org/lrrd20/supplement/sath2.htm

Khang, D.N. and Wiktorsson, H. 2006. Performance of growing heifers fed urea treated fresh rice straw supplemented with fresh, ensiled or pelleted cassava foliage. Livestock Science 102(1-2), pp. 130-139.

Khang, D. N., Wiktorsson, H. and Preston, T. R. 2005. Yield and chemical composition of cassava foliage and tuber yield as influenced by harvesting height and cutting interval. Asian-Australalian Journal of Animal Sciences 18, pp. 1029-1035.

Kokkonen, T., Tesfa, A., Tuori, M. and Syrjälä-Qvist, L. 2004. Concentrate feeding strategy of dairy cows during transition period. Livestock Production Science, vol. 86, no. 1, pp. 239-251.

Leng, R.A. 1984. The potential of solidified molasses-based blocks for the correction of multi-nutritional deficiencies in buffaloes and other ruminants fed low quality agro-industrial by-products. In: The use of nuclear techniques to improve domestic buffalo production in ASIA IAEA Vienna, p. 135 - 150.

Luong Pham, Dominic Smith and Hieu Si Phan. 2015. The Vietnamese Beef Cattle Industry. http://www.asiabeefnetwork.com/country-profiles/viet-nam/cattle-production-systems/

Ly, L. V. 1995. Beef cattle and research results in Vietnam. Agricultural Publishing House, Hanoi, Vietnam.

Meyrelles, L., MacLeod, N. A. and Preston, T. R. 1977a. Cassava forage as a protein supplement in sugarcane diets for cattle: effect of different levels on growth and rumen fermentation. Tropical Animal Production 2:73-80.

Meyrelles, L., MacLeod, N. A. and Preston, T. R. 1977b. Cassava forage as a protein in sugarcane diets for cattle: effects of different levels without urea on growth and on rumen fermentation. Tropical Animal Production 2, pp. 200-205.

Meyrelles, L., MacLeod, N. A. and Preston, T. R. 1977c. Cassava forage as a protein source in sugarcane diets for cattle: effect on rumen fermentation of different levels of cassava forage and urea. Tropical Animal Production 2, pp. 300-305.

Ngoan, L. D., Ba, N. X. and Van, N. H. 2006. Ruminant feed in household condition in central area. Editor: Giang, V.D. Vietnam agricultural publishing House.

Ngoc, T. T. B., Len, N. T. and Lindberg, J. E. 2012. Chemical Characterization and Water Holding Capacity of Fibre-rich Feedstuffs Used for Pigs in Vietnam. Asian-Australalian Journal of Animal Sciences Vol. 25, No. 6, pp. 861-868.

NIAS. 2001. Composition and nutritive value of animal feed in Vietnam. National Institute of Animal Science, Vietnamese Agricultural Publishing House, Hanoi, Vietnam.

Patrick C. Hoffman., Shaver, R. D. and Undersander, D. A. 2016. Utilizing Corn Stalk Residues for Dairy Cattle. https://fyi.uwex.edu/forage/files/2016/10/UtilizingCornStalkResiduesforDairyCowsandHeifersv3.0.pdf

Phu Thinh Company. 2012. Chemical compositions and nutritive value of rice bran with 4-11% fiber content. https://phuthinhco.wordpress.com/2012/07/31/thanh-phan-va-gia-tri-dinh-duong-cua-cam-gao-chat-xo-4-11/

Poulton, J. E. 1988. Localization and catabolism of cyanogenic glycosides. In: Cyanide Compounds in Biology, pp. 67-91. DOI: 10.1002/9780470513712.ch6.

Pradhan, R., Tobioka, H. and Tasaki, I. 1997. Effect of moisture content and different levels of additives on chemical composition and *in vitro* dry matter digestibility of rice straw. Anim. Feed Sci. Technol. 68, pp. 273-284.

Prasad, R. D. D., Reddy, M. R. and Reddy, G. V. N. 1998. Effect of feeding baled and stacked urea treated rice straw on the performance of crossbred cows. Animal Feed Science Technology 73, pp. 347-352.

Preston, T. R., 2001. Production and utilization of cassava in intergrated farming system for smallholder farmers in Vietnam and Cambodia. www.researchgate.net/publication/237331716

Ravindran, V. 1993. Cassava leaves as animal feed: potential and limitations. Journal of Science Food Agriculture 61, pp. 141-150.

Reed, J. D., 1995. Nutritional toxicology of tannins and related polyphenols in forage legumes. Journal of Animal Science 73(5), 1516

Saadullah, M., Haque, M. and Dolberg, F. 1981. Treated and untreated rice straw to growing cattle. In: Proceedings of the Second Annual Seminar on Maximum Livestock Production from Minimum Land. Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 136. 155.

Salim, H. M., Shahjalal, M., Tareque, A. M. M. and Kabir, F. 2002. Effects of concentrate supplementation on growth and reproductive performance of female sheep and goats under grazing condition. Pakistan Journal of Nutrition, vol. 4, pp. 191-193.

Sarnklong, C., Cone, J. W., Pellikaan, W. and Hendriks, W. H. 2010. Utilization of Rice Straw and Different Treatments to Improve Its Feed Value for Ruminants: A Review. Asian-Australalian Journal of Animal Sciences 23(5), pp. 680-692.

Schiere, J. B. and Ibrahim, M. N. M. 1989. Feeding of ureaammonia treated rice straw: A compilation of miscellaneous reports produced by the Straw Utilization Project (Sri Lanka). Pudoc, Wageningen.

Seng Mom, Preston, T. R., Leng, R. A. and MeulenUter. 2001. Response of young cattle fed rice straw to supplementation with cassava foliage and a single drench of cooking oil. Livestock Research for Rural Development (13). http://www.lrrd.org/lrrd13/4/seng134.htm

Sharma, D. D. and Singh, K. K. 1988. Processing of complete feeds for ruminants. In: Proceding of National Seminar cum Workshop and Exhibition on Dairy products and Equipments. IDA, Delhi, India.

Sheikh GG, Ganai AM, Reshi PA, Sheikh Bilal, Shabir Mir and Danish Masood, 2018. Improved Paddy Straw as Ruminant Feed: A Review. Agricultural Reviews, 39(2): 137-143.

Shen, H. S., Ni, D. B. and Sundstøl, F. 1998. Studies on untreated and urea-treated rice straw from three cultivation seasons: 1. Physical and chemical measurements in straw and straw fractions. Animal Feed Science Technology 73, pp. 243-261.

Silva, A. T. and Ørskov, E. R. 1988. The effect of five different supplements on the degradation of straw in sheep given untreated barley straw. Animal Feed Science Technology 19, pp. 289-298.

Sirohi, S. K. and Rai, S. N. 1995. Associative effect of lime plus urea treatment of paddy straw on chemical composition and *in vitro* digestibility. Indian Journal of Animal Science 65, pp. 1346-1351.

Stanogias, G. and Pearce, G. R. 1885. The digestion of fibre by pigs 1. The effects of amount and type of fibre on apparent digestibility, nitrogen balance and rate of passage. British Journal of Nutrition 53, pp. 513-530.

Sundstøl, F. and Coxworth, E. M. 1984. Ammonia treatment. In: Straw and Other Fibrous By-products as Feed (Ed. F. Sundstøl and E. Owen). Developments in Animal Veterinary Sciences, 14. Elsevier, Amsterdam, pp. 196-247.

Szyszkowska, A., Sowiński, J. and Wierzbicki, H. 2007. Changes in the chemical composition of maize cobs depending on the cultivar, effective temperature sum and farm type. Acta Scientiarum Polonorum. Agricultura (Poland) 6, pp. 13-22

Tao, N. H., 1996. Study on processing and preservation of groundnut vines by ensiling as dairy cattle and pig feed. Doctoral thesis.

Tham, P. D., Quang, N. H., Khoa, M. A. and Ngoc, H. T. B. 2015. Utilization of urea-treated rice straw and cassava root silage in cattle smallholder farm in the Northwest region. Journal of Animal Science and Technique 12 (201), pp. 47 - 52.

Thang, C., Ledin, I. and Bertilsson, J. 2010. Effect of feeding cassava and/or Stylosanthes foliage on the performance of crossbred growing cattle. Tropical Animal Health and Production 42(1), pp. 1-11.

Tiwari, S. P., Singh, U. B. and Mehra, U. R. 1990. Urea mineral molasses block as feed supplement on digestibility and growth in buffalo calves. Animal Feed Science and Technology 29 (3-4), pp. 333-341

Trach, N. X. and Nhac, T. V. 2008. Effect of age and concentrate level on weight gain and economic efficiency of finishing local cattle in Krong Pa district, Gia Lai province. Hanoi Agricultural University, Journal of Science and Development. No. 4, pp. 343 - 347.

Trach, N. X., Dan, C. X. and Huong, H. T. 1999. Effect of urea, lime and urine treated rice straw on dry matter degradation in cattle rumen. Research results on animal sciences and veterinary 1996-1998, Hanoi University of Agriculture. Agricultural Publishing House, Hanoi, Vietnam.

Trung, N. T. 2014. Nutritive values of selected forages for ruminants in Vietnam. Supplementation of varying level of cassava root meal and groundnut cake during growing phase, and its effect on performance of Laisind cattle in the finishing phase. PhD Thesis. Thesis number 2014:82, ISSN 1894-6402, ISBN 978-82-575-1241-5. Norwegian University of Life Sciences.

Truong La. 2011. Using corn cobs in fattening cattle diets. http://www.vusta.vn/vi/news/Thong-tin-Su-kien-Thanh-tuu-KH-CN/Su-dung-loi-ngo-trong-khau-phan-vo-beo-bo-thit-39327.html

Truong La. 2012. Application of some technical solutions to develop cattle production for ethnic farmers in Tay Nguyen. Final report on Science and Technology project from ADB loan.

Tuan, T. V. 2015. Study on some technical solutions and market to enhance meat production and economic efficiency of fattening cattle in the Northwest region. Doctoral thesis, National Institute of Animal Sciences.

Tufarelli, V., Dario, M. And Laudadio, V. 2009. Forage to concentrate ratio in Jonica breed goats: influence on lactation curve and milk composition. Journal of Dairy Research, vol. 76, pp. 124- 128.

Vadiveloo, J. 2003. The effect of agronomic improvement and urea treatment on the nutritional value of Malaysian rice straw varieties. Animal Feed Science and Technology 108, pp. 33-146.

Van, D. T. T. 2014. Study on suitable diets for fattening F1 ½ Droughtmaster cattle. Summary Report of Science and Technology 2014. Ministry of Agriculture and Rural Development.

Vikers, M. and Stewart, K. 2016. Feeding growing and finishing cattle for Better Returns. Beef BRP manual 7. http://beefandlamb.ahdb.org.uk/wp/wp-content/uploads/2016/12/BRP-Feeding-growing-and-finishing-manual-7-091216.pdf

Vu, D. D., Cuong, L. X., Dung, C. A. and Hai, P. H. 1999. Use of urea-molasses-multinutrient block and urea-treated rice straw for improving dairy cattle productivity in Vietnam. Preventive Veterinary Medicine 38, pp. 187-193.

Waghorn, G., Jones, W., Shelton, I. and McNabb, W. 1990. Condensed tannins and the nutritive value of herbage. In: Proceedings of the New Zealand Grassland Association 51, pp. 171-176.

Wanapat, M., Kang, S., Hankla, N. and Phesatcha, K. 2013. Effect of rice straw treatment on feed intake, rumen fermentation and milk production in lactating dairy cows. African Journal of Agricultural Research, Vol. 8(17), pp. 1677-1687

Wanapat, M. 2009. Potential uses of local feed resources for ruminants. Tropical Animal Health and Production 41(7), pp. 1035-1049.

Wanapat, M. 1999. Feeding of ruminants in the Tropics based on local feed resources. (Ed. M. Wanapat). Department of Animal Science, Khon Kaen University, Khon Kaen, Thailand.

Wanapat, M., Pimpa, O., Petlum, A. and Boontao, U. 1997. Cassava hay: A new strategic feed for ruminants during the dry season. Livestock Research for Rural Development 9(2), pp. 1-5.

Waterman, P. G. 1999. The tannins - an overview. In: Proceeding of International Workshop on Tannins in Livestock and Human Nutrition. Australian Centre for International Agriculture Research, Adelaide, Australia.

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