THE UTILIZATION OF CASSAVA FORAGE IN RUMINANT FEEDING *

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INTRODUCTION

The plant botanically described as *Manihot esculenta* Crantz is known around the world by many different names such as cassava, tapioca, manioc, maniok, mandioca, aipi, and yuca. Plants of the genus *Manihot* occur naturally only in tropical America, where about 100 different species are known (Rogers and Fleming, 1973). Cassava was used in South America as a food plant by the native Amerindians long before Columbus discovered the New World and was probably transported by the Spanish and Portuguese to Africa and Asia as early as the 16th Century. Its diffusion within the Continent of Africa has come about most rapidly during the 20th Century (Coursey and Halliday, 1974).

In terms of production, cassava ranks among the top 10 food crops in the world and appears to be increasing in importance. In 1972 the world production was estimated at 105 millon tons of fresh roots, produced from a land area of 11 million hectares (Table 1). Considering the fact that cassava ranks among the top ten food crops in the world, it has received relatively little attention from the research scientist. The scientific cassava documentation

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Center located at CIAT in Cali, Colombia, estimates that no more than 4,000 scientific and popular articles exist about cassava.

TABLE 1. WORLD DISTRIBUTION OF CASSAVA PRODUCTION

Major Areas	Area 000 Acres	Production 000 Tons Fresh roots
Africa	5,996	42,220
Zaire	810	10,500
Nigeria	960	9,570
Tanzania	800	6,000
South America	2,549	36,168
Brazil	2,100	31,000
Paraguay	125	1,850
Colombia	160	1,600
Asia	2,331	22,188
Indonesia	1,350	10,099
India	355	5,939
Thailand	225	3,867
Central America and Caribbean	110	713
Oceania	11	128
Total World Production:	10,998	105,417

Source : FAO Production Yearbook, 1972

Of those 4,000 articles, probably no more than 5 per cent are related to the use of cassava in animal feeding and the major part of those relate to the use of the root as an energy source with only a few papers dealing with the use of the leaves and stems as a principal source of protein.

The object of this paper is to bring together information that has been published about the utilization of cassava forage (leaves, stems

and stalks) in the feeding of livestock with particular emphasis on ruminants.

Nutritive Value of Cassava Forage

It should be pointed out that most of the existing data on cassava forage has been taken from plants which were planted for root production and not specifically for forage production.

Reports from Peru (Galiano, 1955);Colombia (Obregón, 1968);Nigeria (Oyenuga, 1955);Brazil (Gramacho, 1973) and the United States (Ramos-Ledón and Popenoe, 1970) generally agree on the chemical composition of the aerial part of the plant when harvested at approximately one year of age (Table 2)

TABLE 2. AN APPROXIMATE ANALYSIS OF CASSAVA FORAGE HARVESTED AT ROOT MATURITY.

Analysis	D.M.	Protein	Fat	CH_2O	Fiber	Ash
Cassava forage	25.0	16.0	7.5	45	14.5	12.0

The data presented in Table 2 should be taken as a general guide since climate, soil type, age of harvest, fertilization and sampling procedure may affect the resulting chemical analysis of the plant. It has also been reported that the forage has a significant amount of calcium (.88 per cent CaO);phosphorus (1.0 per cent P_2O_5)and carotene (208,000 I.U./lb) which are also important nutrients provided by cassava forage.

The leaves of the cassava plant have the highest proportion of protein. Ramos-Ledõn and Popenoe (1970),reported an average of 25.5 per cent leaf protein in plants grown in southern Florida, while Rogers (1959) reported a range of from 20.6 per cent to 36.1 per cent leaf protein in different cultivars of cassava found in various parts of Jamaica. The Florida work also showed the per cent protein of the stems to be considerably lower (5.6 per cent) and that a withdrawal of nitrogen from the leaves occurs after the formation of seeds, and root enlargement.

Data collected at CIAT (Moore and Cock) from plants cultivated only for forage production and harvested every 90 days gives a better idea of the chemical composition of the plant at an age when the entire plant is edible (Table 3).

TABLE 3. CHEMICAL COMPOSITION OF 90-DAY-OLD CASSAVA PLANT *

Parts of plant	% of total plant	D.M.	Nitrogen	Prot. (Nx 6.25)	Ether extrac.	Crude fiber	Ash
Leaves (%)	52	29.0	4.38	28.0	15.3	9.0	8.1
Stems (%)	15	18.0	1.65	11.3	14.3	21.9	8.5
Stalk (%)	33	15.7	1.76	11.0	13.0	25.2	7.8

* Unpublished data- CIAT

It can be seen from Table 3 that the leaf portion of the plant contains more than twice the amount of protein (N x 6.25) than the stem or stalk and makes up slightly more than one-half of the total dry matter of the plant at 90 days. The protein and non-protein fractions of the plant have not been determined to date;however, data

published by Oyenuga (1955) suggest that the nitrogen present in the leafy portion may be as much as 90% true protein. Unpublished data of Cock and Echeverry are of the same order. This, however, should not be a major consideration in feeding the plant to ruminants since they are able to utilize non-protein nitrogen as well.

Essentially no work has been done on the selection of cassava plants for forage production or nutrient content. Genetic selection and agronomic practices to increase dry matter production and protein content is an obvious area for future studies.

Agronomic Aspects of Cassava

While no agronomic practices have been developed for cassava as a forage plant, certain comments can be made which apply in general to the plant.

Muller et al (1974) states that cassava grows best in a sandy soil with optimum growing temperature of 27°C. When the temperature drops to 15°C, growth stops;at 8 to 10°C the plant dies. The optimum rainfall is 700 to 1000 mm and large amounts of sunshine are required.

He further states that a 50-ton yield of roots per hectare makes a heavy demand on the land; will remove from the soil approximately 120 kg P_2O_5, 450 kg K_2O and 250 kg CaO. No mention is made of nitrogen depletion; however, leaf production alone would suggest that 400 to 600 kg of nitrogen would be removed from the soil per ha/yr.

All cassava forage production data to date has been in association with root production. Either the leaves have been harvested several

times during the life cycle of the plant or harvested at the time the roots are harvested.

Work done by Conceiçao et al (1973) shows that certain varieties are better forage producers than others and suggests that a negative correlation may exist between root production and forage producing ability (Table 4).

TABLE 4. PRODUCTION OF CASSAVA TOPS AND ROOTS FOR THE YEARS 1969-72

	Average Production (Ton/ha) *			
	Tops	Relative production	Roots	Relative production
Platina	46.79	157	12.52	100
Graveto	37.06	125	20.99	168
Salangor Preta	33.03	111	25.39	203
Mamao	32.29	109	20.77	166
Cigona	30.76	103	21.39	171
Sutinga	29.73	100	18.60	149
Average	34.73			

* Fresh weight

A reduction in root growth would be expected when the branches are harvested three times (every 4 months) during the year. No comparison is made as to the root production of these varieties (Table 4) if no branches were harvested; however, Ahmad (1973) harvested 7.3 tons of leaves (dry weight) during the year (every 10 weeks) from one hectare which reduced the production of roots to almost one-half of the normal. Preliminary results at CIAT (Cock, Pers.Comm.), without intensive

variety selection, indicates that up to 20 tons of forage dry matter per hectare can be harvested in one year. This was accomplished by increasing the plant population from 10,000 plants/ha (normal population for root production) to 111,000 plants/ha. The entire plant was harvested every 90 days, which is equal to 4 cuttings per year. This production level is approximately twice that reported by other workers harvesting the cassava forage in conjunction with the roots. Since the original plantings are still in production (1 1/2 years) no measure has been made of root production.

In similar trials at CIAT, using small plots with 30 x 30 cm spacing, a yield of over 30 t/ha of dry matter was obtained in 11 months at four harvest; at three harvest, yields dropped to slightly more than 25 t/ha. When spacing was decreased to 60 x 60 cm, the yield was further reduced to 16 t/ha. It should be noted that these yields were obtained on intensively managed small plots on a fertile soil.

Considering that the information available to date shows that harvesting leaves from the cassava plant when planted as a root crop will greatly reduce the root production;it appears that separate plantings (for roots or for forage) would produce more total dry matter per hectare.

If certain varieties are better producers of forage and others better producers of roots, varietal selection will be very important.

Toxity Problems in Cassava

It is well known by the scientists working on cassava that the forage and roots contain cyanogenetic glycosides which are readily split by enzymes naturally present in the plant to form free hydrogen cyanide

(HCN). These are normally detoxified in the body with the resulting formation of thiocynates, which can be found in the blood and urine. This cyanide formation has been associated with disturbing thyroid function, and the depletion of the sulphur-containing amino acids (Coursey and Halliday, 1974).

It has not been made clear whether or not the HCN normally occurring in cassava production produces a toxic effect in domestic animals or whether the HCN present is merely tying up some nutrient which could be added to the diet to overcome the deficiency.

It has been reported (Ross and Enriquez, 1969) that cassava leaf meal (554 ppm of HCN) in excess of 10% of the ration will retard growth in baby chicks and is inferior to similar levels of alfalfa meal. In those studies, methionine was suggested as the first limiting factor in the cassava meal and was probably caused by an increased demand for the sulphur-containing amino acids used in the detoxification process of the cyanide. A look at the amino acid profile of cassava leaves and stems (Table 5) shows methionine and cystine (sulphur-containing amino acids) to be low in relation to most other amino acids. This explains why methionine could be limiting if the amounts naturally present are tied up in the detoxification of HCN.

If the HCN content in cassava is proven to be a serious problem in livestock, Obregón (1968) and Galiano (1955) have shown that most if not all, of the HCN can be removed by sun-drying before it is fed to livestock.

TABLE 5. PROTEIN VALUE OF DEHYDRATED AERIAL PART OF CASSAVA PLANT AND SOME TROPICAL GRASSES, COMPARED WITH SOYBEAN MEAL (ON A DRY BASIS)

Constituents	Cassava Manihot utilissima Leaves	Cassava Manihot utilissima Leaves+Stems	Napier grass Pennisetum Purpureum	Gatton panic Panicum maximum	SBMO solvent extracted
Crude protein(%)	27.0	20.3	12.6	11.9	45.7
	g/16g nitrogen				
Amino acids					
Arginine	5.21	3.89	6.10	5.64	7.41
Cystine	1.18	0.98	0.51	-	1.52
Glycine	4.92	5.10	5.85	5.00	5.23
Histidine	2.47	2.32	2.54	2.82	2.39
Isoleucine	4.12	4.40	4.32	3.45	5.45
Leucine	10.09	8.75	8.64	7.55	6.97
Lysine	7.11	5.89	6.02	4.82	6.32
Methionine	1.45	1.83	1.86	1.36	1.52
Phenylalanine	3.87	4.37	5.42	5.82	4.79
Threonine	4.70	5.70	4.41	4.73	4.14
Tryptophan	1.09	1.24	-	-	1.30
Tyrosine	3.97	4.12	3.73	3.18	3.27
Valine	6.18	8.43	6.27	5.18	5.23

Source: Draft feeding standard, Republic of Singapore, 1972.

Further evidence that methionine is limiting in cassava based diets fed to monogastrics has been shown by Eggum (1970), Hutangalung (1972) and Maner (1972), who improved the quality and digestibility of the dietary protein by adding methionine to the diet.

To further verify that the toxic factor in cassava forage caused no physiological problems in ruminants, Moore and Cock (unpublished data), fed fresh cassava forage alone to four two-year-old steers for two months with no visual disorder. Blood thyocinates levels in the fresh cassava-fed steers (3.9 mg/%) were three times greater than steers (1.28 mg/%) grazing pará (Brachiaria mutica) pasture. In a separate trial, pure diets of fresh cassava forage were fed to a small group of sheep in confinement with no visual adverse effects. Hill (1973) also reported that feeding either cassava forage or roots had no adverse effects in cattle or sheep.

Feeding Value of Cassava Forage

The limited research work that has gone into determining the chemical composition and protein quality of cassava forage has been largely restricted to the leaf, as a protein source for humans.

The nutrive value of the leaves is recognized as they constitute part of the human diet in parts of Africa. Efforts have been made to extract the protein from the leaves; however, the process is very sophisticated and relatively expensive.

Factors such as a long growing season, low dry matter production and irregular harvesting are probably some of the reasons why only a few research papers exist on the utilization of cassava forage in ruminant feeding. In addition, the most common systems for beef and milk

production in the tropics do not presently lend themselves to the feeding of cut forages.

However, as the demand for high quality protein (meat and milk) increases along with the increased demand for alluvial lands for cereal grains, the cattleman will have to look for ways of intensifying his operation. One way will be to grow cultivated tropical forage crops such as elephant grass, sugar cane, corn, sorghum, etc. to be combined with legumes, oil seed meals and non protein nitrogen as sources of supplemental protein.

In many tropical countries, beef-type animals are being used as dual-purpose animals to produce both meat and milk, since no dairy-type cow has been developed which can thrive in the tropical environment. The cyclic production of these animals, which is well known by everyone working in the tropics, is largely related to the rainfall pattern and thus the pasture feed supply of the zone.

Cows tend to conceive a month or so after the rains begin which means they give birth at the beginning of the dry season. If they must nurse a calf and are milked during the dry season, when both quantity and quality of forage are low, they will suffer a great physiological shock due to undernutrition. The result is low milk yields, and a weak cow that goes into an anestrous period lasting for several months or until she can build back body tissues. This will take her well beyond the normal breeding season and thus result in a calf produced approximately every two years.

This phenomenon can be avoided (assuming climatic changes are not greatly affecting reproduction) by developing pastures which will grow

and provide adequate nutrients during the dry season, or by growing cultivated forage crops during the rainy season and preserving them for the dry season. Several alternative solutions have been presented (Preston 1975) as to how cultivated forages and other by-products can be utilized to eliminate weight losses and increase reproductive efficiency. Preston also points out that while ruminants can utilize a rather high level of non-protein nitrogen they still require a dietary source of performed protein.

Cassava forage has a great potential as a protein source. Echandi (1952) in Costa Rica showed that cassava forage meal was almost as good as alfalfa meal. Grazing milk cows receiving cassava meal gave 90 to 96% as much milk as those receiving equal amounts of alfalfa meal. Since the alfalfa meal was imported, it became the more expensive supplement even though it produced slightly more milk per kilogram fed.

To evaluate the effects of feeding fresh cassava forage on growing animals, a trial was designed (Moore and Cock, unpublished data) to feed 250 kg steers in corrals on either: (A) elephant grass alone; (B) 75% elephant grass + 25% cassava forage;or (C) 50% elephant grass + 50% cassava forage. Both groups B and C gained 30% faster than group A. Group B (25% cassava forage) gained 4% faster than group C (50% cassava forage) suggesting that the protein level in ration B was nearly adequate and that energy became limiting in ration C (Table 6).

TABLE 6. ELEPHANT GRASS AS A GROWING-FINISHING RATION SUPPLEMENTED WITH CASSAVA FORAGE

Parameters	Diet A Eleph.grass alone	 B 75% eleph.grass 25% cassava forage	 C 50% eleph.grass 50% cassava forage
Initial weight (kg)	265.5	276.3	270.0
Final weight (kg)	342.5	392.7	379.0
A D G (g)	306.0	461.0	445.0
Dry matter consumed (kg/da)	5.4	6.3	6.1
Crude protein (%)	6.0	9.7	13.0
Feed efficiency	17.6	13.7	13.7

The animals on elephant grass alone ate 22 per cent more feed (17.6 kg per kg of live weight gain) than did either group B or C (13.7:1). The inefficient conversion of feed to gain appeared to be related to the low protein content of the elephant grass.

As a follow-up to that experiment another trial was designed to compare cassava forage to other sources of protein, i.e. fresh Desmodium distortum and cottonseed meal (CSM). In this trial, mature sugar cane was used as the major source of energy. The cane was allowed to reach maturity (12 to 14 months of age) before cutting, which corresponds to the age that it is harvested in the Cauca Valley of Colombia for sugar production.

Desmodium distortum was selected as another source of protein because of its high protein content (23 per cent) and because of its growth style which lends itself to easy harvesting. One problem associated with Desmodium distortum is that it is an annual species and while 3 to 4 cuttings (intervals of 60 days) can be obtained, total dry matter production declines with each subsequent cutting (Paladines, Pers.Comm.).

All three forage species were offered fresh daily and in separate feeders, ad libitum, to determine individual consumption of each. The CSM was fed once daily on top of the sugar cane. Each animal was maintained in individual pens.

The animals in treatment I (cane and CSM) gained 7 per cent faster (659 g/da) than treatment II (622 g/da) and 11 per cent faster than animals in treatment III (584 g/da) (Table 7).

The average daily dry matter consumption was essentially the same for all treatments (5.3, 5.2, 5.2, respectively) whereas the efficiency of converting feed to live weight gain was more varied. The steers receiving CSM were 5% more efficient than those receiving cassava and 11 per cent more efficient than those receiving Desmodium distortum. It is very noticeable that the percentage difference between treatments in average daily gain was similar to that found between differences in feed efficiency.

However, when efficiency of gain is related to the amount of protein consumed, the relationships change. Since two protein sources were fed as fresh forage (ad libitum) and one was fed as a dry concentrate,

there was a large difference in daily protein intake due to the difference in moisture and protein content. The protein (N x 6.25) consumed per day by those animals on CSM was roughly double that consumed by the other two groups. This suggests that approximately 1.4 kg of protein was consumed per kg of live weight gain in group I while only 0.7 kg of protein was consumed per kilogram of live weith gain in group II and III.

TABLE 7. PERFORMANCE OF GRADE ZEBU STEERS FED CHOPPED SUGAR CANE PLUS THREE SOURCES OF PLANT PROTEIN

Parameters	Treatments * I	II	III
	Sugar cane plus 1.8kg CSM	Sugar cane and cassava	Cassava and *D. distortum*
No. animals	8	8	8
Initial weight (kg)	229.5	241.4	241.0
Final weight (kg)	303.3	311.1	306.4
Days on trial	112.0	112.0	112.0
Average daily gain (kg)	.659	.622	.584
Feed efficiency	8.0	8.4	9.0
Avg.daily dry matter consumption (kg)	5.3	5.2	5.2

* All forages where fed ad libitum.

A possible explanation for this difference in protein utilization would be that group I was fed an excessive amount of protein which was inefficiently utilized or that the forage protein sources provided

other nutrients not present in the cane plus CSM diet. Minerals should not be a consideration since all animals were offered a complete mineral mix free choice;however, the relatively high content of fat especially in the cassava forage may have had a positive effect on live weight gain and feed efficiency.

The steers in group II ate 20 per cent less cassava forage (1.52 kg/da) than those receiving Desmodium distortum forage (1.94 kg/da), but they ate 11 per cent more cane per head/da. The lower intake of cassava could represent a palability problem with the cassava due to its bitter taste caused by the HCN content. However, the data suggest the HCN content of the cassava did not affect the average daily gain, nor feed efficiency of these steers consuming diets with 30 per cent of the total as cassava forage.

Economic Implications of Cassava Forage Production

Since the cassava plant has never been looked at as a major source of protein for livestock feeding, no data exists relative to production cost. However, it would appear reasonable to use figures published by Díaz, Andersen and Estrada (1974) on the cost of producing cassava roots in Colombia as a base line estimate for producing cassava forage (Table 8).

Thirty per cent was added to the US dollar cost for increased seed and harvest cost due to an increase in the plant population per hectare plus 4 harvests during the year to give a more realistic estimate of the production cost of one hectare of cassava forage (US$ 428.09/ha).

TABLE 8. ESTIMATED AVERAGE TOTAL COST OF CASSAVA PRODUCTION IN COLOMBIA

Inputs	Col.Pesos/ha.	US$/ha.*
Average variable cost	2.390	119.50
Land rent	1.800	90.00
Transportation cost	720	36.00
Interest on working capital	576	28.80
Other costs	1.100	55.00
Total cost	6.586	329.30

* Exchange rate 20:1

Preliminary results (Cock, Pers.Comm.) have shown that the production of over 20 metric tons of dry matter is possible from one hectare of good land (capable of producing 50 tons of roots). Using the previously mentioned production cost figures (US$428.00/ha); one kg of dry matter would cost slightly more than US 02¢. One kg of protein (N x 6.25) would then cost (US.02 x 20 per cent protein) US.10¢. Table 9). As a comparison, one kg of cottonseed meal (48 per cent protein) in Colombia presently costs US.15¢ which is equal to US.31¢ per kg of protein. One kg of urea, which is said to be cheapest source of protein (262 per cent protein equivalent) in Colombia, presently costs US.24¢;equal to US.09¢ per kg of protein equivalent, or one cent less than the cost of one kg protein from cassava forage.

TABLE 9. COSTS OF SEVERAL SOURCES OF PROTEIN IN COLOMBIA

	Per kg dry matter	Per kg protein
Cottonseed meal	US$.15	US$.31
Cassava forage	.02	.10
Urea	-	.09

Using the present cost of producing sugar cane in the Cauca Valley of Colombia (US$625/ha) with a production of 50 tons of dry matter (whole plant) per hectare, the cost of one kg of dry matter would be US.012. The daily production cost of the cassava/sugar cane diet in this experiment would then be (1.52 kg cassava X US.02=US.03) + (3.70 kg sugar cane X US.012=US.04)=US.07 or 1.3 cents per kg of feed consumed. Taking the present market price of fat steers in Colombia of US.48 per kg live weight and an average daily gain of .62 kg, the feed production cost per kg of gain (US 11¢) would represent only 23 per cent the value of one kg of gain, whereas the CSM/sugar cane diet cost, per kg of gain (US 40¢), was equal to 83% of the value of one kg of gain in this experiment. (Table 10). It should be stressed that the protein content in ration I was probably higher than necessary and attributed to the higher cost of the ration. Also, the forage production figures presented in this paper are from the Cauca Valley of Colombia and would be nearer a maximum possible than an average for the tropics. However, there should be little doubt that cassava forage can play a very important

role in ruminant feeding in the tropics, whether it be used as part of a fattening ration or in a dry season supplement program for the breeding or milking herd.

TABLE 10. COSTS OF PRODUCTION

	Dry matter ha	Cost/ ha US$	Cost/ kg	Daily consumption kg	Daily cost US$
Sugar cane	50 ton	625.00	.01	3.70	.04
Cassava forage	20 ton	428.00	.02	1.52	.03
				TOTAL	.07

Average daily gain	.62 kg
Live weight value	US$.48 kg
Value of daily gain	US$.30

Summary

The nutritive value of cassava as a forage is little known and even less utilized in its native tropical regions of the world. This paper shows that cassava forage is a good source of protein for ruminants and competes well with other sources of plant protein as measured by animal performance. The dry matter production per ha/yr (20 ton) is very high, relative to other tropical plants high in protein, which makes it attractive as a forage plant. A population of 111,000 plants/ha and a harvesting interval 90 days gave the highest yields.

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