THE USE OF SWEET POTATO (*Ipomoea batatas*, (L) Lam) IN ANIMAL FEEDING II BEEF PRODUCTION

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3.5 ha of sweet potato were used to feed 30 crossbred Brahman bulls with an average weight of 184 kg and approximately one year old in an experiment to study the use of sweet potato in beef production.

The five treatments were allocated to the experimental units in an unrestricted randomized block design. Treatments contained 0:100, 25:75, 75:25, 50:50 ant 100:0 ratios of tubers to sweet potato forage (on a try matter basis) supplemented with urea to provide 0, 18, 35, 53,and 71% of total nitrogen respectively. An additional treatment of 38.6% molasses, 60.2 of the aerial parts of sweet potato and 1.2% urea was also used with. the aim of comparing its effect with the 100% tuber treatment under the same conditions of energy and protein. All the rations contained 11.25% of crude protein.

Food intake did not vary averaging 2.37 and 0.29 kg/100g LW/d for dry matter and crude protein respectively. The mean energy intake was 5.57 Mcal metabolizable energy/100 kg LW/d and this increased as the proportion of tubers in the ration increased. In addition, dry matter digestibility increased from 62 -92% as the proportion of tubers increased, The molasses treatment resulted in slightly higher intakes (2.75 kg/100 kg LW) even though its in vitro digestibility was lower (56%).

Liveweight gain did not differ significantly between treatments. The mean being 0.767 kg/animal/d. The mean feed conversion efficiency was 7.06kg DM/kg LW gain. In the molasses treatment liveweight gain and feed conversion efficiency were poorer compared to the 100% tuber treatment, the values obtained were 0.623 kg/animal/d and 9.0 kg intake/kg gain.

Economic considerations revealed that 12% of the tubers had no commercial value. The use of this material together with the sweet potato forage for feeding to the cattle, could produce a profit of 38% thus providing a new' alternative for the livestock producer.

From these results we can conclude that the forage and the tuber of sweet potato can be considered as a very useful feed for cattle; that the addition of tubers and urea to forage improves liveweight gain and feed conversion efficiency and that the we of forage and west. tubers of sweet potato as a feed for livestock has economic advantages for the small producer.

Key words: Sweet potato, feeding-of butts, intake of forage and tubers, bio-economic efficiency

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Agricultural plants like sweet potato, besides yielding commercial products yield residues which can be used for animal production. The potential production of certain varieties of sweet potato can reach 25 tonnes of tubers/ha/ harvest (More Vargas 1969; Zumbado 1967; Pinchinat 1970; Ruiz et al 1980). Production of forage ranges from 4.0 - 5.6 tonnes DM/ha/harvest depending on the variety (Ruiz et al 1980). The chemical composition of the forage shows DM contents of 12 - 17% and DM digestibility of greater than 70% (Ffoulkes et al 1978; Ruiz et al 1980).

In beef production in temperate zones dried tubers have replaced traditional energy sources such as maize, producing weight gains of up to 1 kg/headld (Darlow et al 1950). Increases in vitamin A content in milk and increased milk production of up to 0.79 kg/cow/d have been recorded when sweet potato tubers have been fed (Jennings et al 1948; Mather et al 1948; Lush 1936; Massey et al 1976).

The high yields of organic matter from sweet potato together with the results described, suggest that the use of the biomass of this plant as a cattle feed could help to solve the problems of feed shortage in the tropics, and thus increase the availability of high quality foods for humans. The present study was designed with the objectives of: a) evaluating the sweet potato forage and tubers in feeding beef bulls and b) estimating the potential economics of sweet potato in beef production aimed at high biological efficiency.

Materials and Methods

Statistical design and treatments: An unrestricted randomized design was used comparing the following five ratios of sweet potato tubers to forage(on a DM basis) 0:100, 25:75, 50:50, 75:25, 100:0. Urea was added to these combinations to equalise intake (11.25% total CP); the forage contained this level of protein and therefore no urea was added to the 100% forage ration. A mix of bone meal and salt was also offered ad libitum and vitamins and trace minerals were added. (Table 1).

Table 1: Description of treatments.

Treatment (tuber:forage)	Composition in the DM			Ratio of urea to total N[1] %	ME[2] MCal/kg DM
	Tuber %	Forage %	Urea %		
0:100	0.0	100.0	0,0	0.0	2.1
25:75	24.7	74.2	1.1	18.5	2.2
50:50	49.1	49.1	1.8	35.7	2.4
75:25	73.2	24.4	2.4	53.5	2.5
100:0	96.9	0.0	3.1	70.8	2.5
Additional treatment[3]	Molasses 38.2	Forage 60.2	Urea 1.2	30.0	2.5

[1] In all rations, N x 6.25 - 11.25% of total dry matter (DM)

[2] Metabolizable energy, calculated from McDowell et al (1974)

[3] Designed to compare with treatments 0:100 & 100:0

Procedure: The biomass (forage and tubers) of sweet potato variety C-15 from 3.5 ha was used. It was sown sequentially at a rate of 0.7 ha/month and harvested 5 months later. The spacing of the stands was 0.5 m between rows and 0.4 m between plants. Cross-bred Brahman bulls with a mean liveweight of 184 kg and one year old were used in the experiment; they were offered chopped tubers and forage in the ratios described earlier.

Treatments: The bulls were fed ad libitum and the quantity and composition of the refusals after 24 hours were measured. Samples of the rations and refusals were taken weekly for chemical analysis and in vitro digestibility (Tilley and Terry 1963). The animals were weighed every two weeks and daily liveweight gain estimated by linear regression.

Results and Discussion

Intake and in vitro digestibility of the feed: Table 2 summarizes the data on intake and shows that this was relatively constant between the differ ent ratios of tubers to forage in terms of both DM and crude protein (CP). The mean DM intake was 2.37 kg/100 kg liveweight(LW)/d very similar to that recommended by NRC (1976) for animals of the same weight gaining .75 kg/d. Based on these results the acceptability of rations based on sweet potatoes is taken to be normal. The intakes of protein were also similar to those recommended by NRC (1976).

Table 2:
Intake data as a percentage of liveweight

Treatment (tuber:forage)	Ratio tuber/forage	Observed intake			
		DM kg	Ratio	CP kg	ME[1] MCal
0:100	0.00	2.45	0.00	0.30	5.05
25:75	0.33	2.32	0.45	0.27	5.19
50:50	1.00	2.34	1.16	0.29	5.53
75:25	3.00	2.39	3.60	0.27	5.74
100:0	∞	2.41	∞	0.30	6.34
Mean	----	2.37	----	0.29	5.57
Additional treatment of molasses and forage	----	2.75	----	0.30	6.81

[1] Metabolisable energy calculated from McDowell et al (1974)

The intake of energy increased as the proportion of tubers increased. This would be expected, due to the high starch content (Montaldo 1972) and low cell wall constituents (Ruiz et al 1980) in the tuber, giving a higher energy content than in the forage (McDowell et al 1974).

The results in Table 2 also show that the ratios of tubers to forage actually consumed, differed only slightly from the proportions offered. We can infer from this that neither of the two components resulted in selection due to detrimental effects on intake. The actual ratios consumed were used in the regression analysis of liveweight gain and feed conversion efficiency. The addition of molasses to sweet potato forage led to greater acceptability judging by the increased intake compared to the other treatments (2.75 vs 2.37 kg DM/ 100 kg LW/d). From the estimated energy value of molasses (3.47 Mcal ME/kg DM) the intake of DM would have been greater than for the 100% tuber ration.

The in vitro digestibility results are presented in Table 3. As opposed to the constant intakes, digestibility varied, increasing proportionally with the increase in tuber content in the rations. This may indicate that intake was being limited by chemical or thermal factors (Jones 1972). However, if this was true even higher intakes should have been recorded according to the data of Conrad et al (1964) and Montgomery and Baumgardt (1965). This discrepancy could perhaps be attributed to urea reducing the acceptability of the rations, since at higher proportions of tubers, the percentage of N present as non-protein (NPN) increased from 0- 71% as shown in Table 1.

Table 3:
In vitro digestibility of the experimental rations

Treatment (tuber:forage)	In vitro digestibility of the dry matter %
0:100	62.0
25:75	66.0
50:50	86.0
75:25	99.0
100:0	92.0
Additional treatments of forage and molasses	53.0

From the data in Table 3 the digestibility of forage can be calculated as 62% less than that found in other studies (Ffoulkes et al 1978; Ruiz et al 1980) and in particular Ruiz et al (1980) reported a value of 72% with the same variety C-15, in experiments similar to the present study. The data indicated that sweet potato tubers can be classified as feeds of high energy value, since in vitro digestibility was 92% and the content of starch was also high.

Weight gain and efficiency of feed conversion: The data on weight gain and efficiency of feed conversion are presented in Table 4.

Table 4:
Weight gain and feed conversion efficiency of young bulls fed combinations of sweet potato tubers and forage

Treatment tuber : forage	Weight gain kg/animal/day	Conversion efficiency feed/gain
0:100	0.656	8.51
25:75	0.709	7.39
50:50	0.847	6.24
75:25	0.805	6.51
100:0	0.823	6.63
Additional treatments of molasses & forage	0.623	8.98

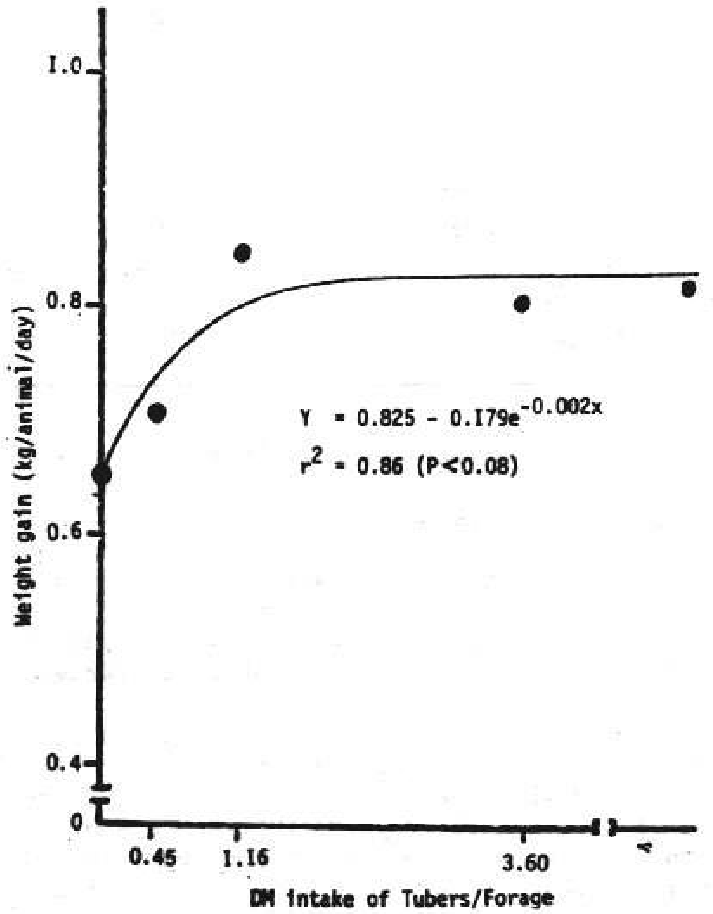
From Table 4 it can be seen that weight gain increased with increasing percentage of tubers until a value of 0.847 kg/animal/d was reached, on a diet where the ratio of forage to tubers was 50:50. The growth rate was lowest at zero percentage tubers where it was similar to the treatment based on molasses and sweet potato forage. m e trends in liveweight gain are shown in Figure 1, but the treatment differences were not significant.

The regression analysis showed an increase in weight gain up to 0.847 kg/animal/d which was obtained when the ratio of tubers to forage was 2.3, i.e when the diet contained 70% tubers and 30% forage (on a DM basis). With higher proportions of tubers the weight gain hardly changed, possibly due to a lack of protein, since as mentioned earlier, all rations contained 11.25% CP and the proportion of NPN increased with the proportion of tubers. One can assume that the biological value of urea is low compared to other N sources (Grainger et al 1960; Oltjen and Putnam 1966) and thus the lack of protein would become more important as the percentage of tubers, and thus urea, increased. The exact explanation cannot be obtained from the present data since the levels of tubers and urea are confounded and there are restrictions of age, weight and gain of the experimental animals.

In order to compare the different types of carbohydrate, the comparison of the 100% tuber ration and the ration based on molasses and forage was made on an isoenergetic and isonitrogenous base. From Table 4 we can see that sweet potato is a better source of energy than molasses in promoting liveweight gain. Also Table 3 indicates that in vitro digestibility of the molasses ration was lower than in all other treatments. This last point could indicate a detrimental effect on cellulolytic activity (White et al 1973) which in turn affects rate of gain thus resulting in poorer results than obtained with starch (e.g. sweet potato tubers) as was also found by Herrera and Ruiz (1976).

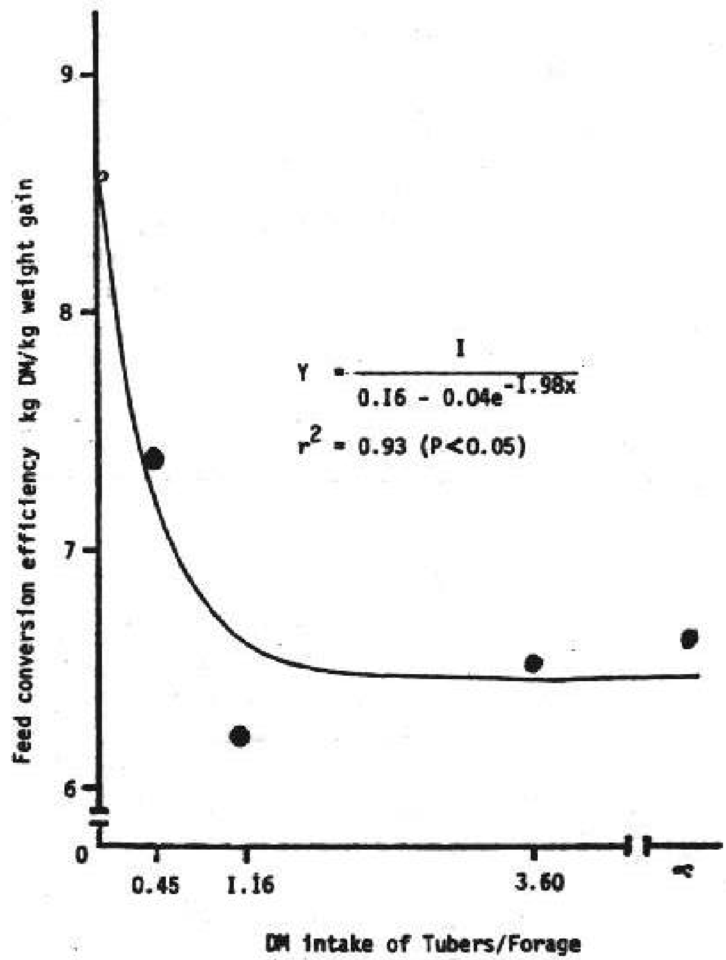
Ffoulkes et al (1978) suggested that sweet potato is superior to other forages in that its protein is not very soluble in the rumen. If we accept this hypothesis, the increase in proportion of tubers and the decrease in forage will decrease the quality of the N component of the ration' However, live weight gain improved without a change in intake showing the advantage of starch as a source of energy in cattle feeding.

Figure 1:
Weight gain (kg/animal/day) as a function of the ratio of intake of sweet potato tubers: forage



The feed conversion efficiency data were also analysed by regression as shown in Figure 2. As one would expect from the results of intake and liveweight gain the efficiency of feed conversion (FCE) improved as the proportion of tubers increased up to the ratio 70:30 tubers to forage when the FCE was 6.45 kg DM/kg gain. Although this value is slightly higher than those given by NRC (1976) it is better than those found by Clavo (1974) and Campion (1973) who obtained indices of 7.4 and 8.1 with rations based on molasses and better than the value of 9.0 on the molasses rations in this study. It would appear therefore that this percent tubers provided a source of starch and structural carbohydrates which gave an efficient microbial synthesis in the rumen even at high levels of urea. This hypothesis is backed by the results of other workers who have used starch as an energy source (Schwartz et al 1964; Styler et al 1971). Obviously the FCE values reflect the high digestibility of the sweet potato forage.

Figure 2:
Feed conversion efficiency as a function of the ratio of intake of sweet potato roots:forage



Economic considerations: The biological results show that it is worth considering sweet potato as a cattle feed;using all the forage and the 12% of tubers which do not qualify for sale. This percentage is the value found in the literature for the proportion of damaged tubers which are unsuitable for retail (Zumbado 1967; Mora Vargas 1969; Brioso de Leon 1979). The sweet potato variety used in the present study produced 15 tonnes/ha of tubers (30.1% DM, 3.4% CP) and 13 tonnes/ha of forage (16.8% DM, 11.25% CP). The analytical results are shown in Table 5.

Table 5 represents a model of a combined operation, aimed at integrating the use of sweet potato. Besides the economic advantages of the plant (290% profit including the interest on the total investment), the integration of an operation with meat animals permits the transformation of damaged material into a high quality human food with additional economic advantages (38% profitability). The costs include the interest on all invested capital including the purchase of animals at $US 1.00/kg liveweignt.

If the yield of 23 tonnes of tubers and 33 tonnes of forage/ha are considered (Brioso de Leon 1979; Ruiz et al 1980)a similar analysis gives 385% profit for the agronomic side and 46% for the livestock side; this includes 12.3 animals of 184 kg initial weight and a daily gain of .69 kg/head.

From the results presented, it is evident that both forage and tubers of sweet potato are an acceptable feed for livestock and that the combination of forage with the starch in the tuber and moderate levels of urea allows high rates of liveweight gain and high profitability.

Table 5:
Model of agronomic production from one hectare of sweet potato

Tuber production		Meat production	
Variety	C-15	Forage production (16.85 DM),tonnes	13
Cultivation cycle (days)	150.0	Non-saleable tubers (30.1% DM),tonnes	1.8
Tuber production (t)	15.0	Urea (for 100 days) (kg)	14.8
Saleable tubers (t)	13.2	Minerals and vitamins (kg)	26.0
Labour costs, US$		Number of animals	5.2
Preparation of soil	60.4	Initial weight of animals	184.0
Seeding	71.7	Days of feeding	100.0
Manure, weed control	23.6	Ratio tuber:forage	0.25
Manual weeding	63.4	Intake (kgDM/animal/day)	5.2
Harvest	85.6	Weight gain (kg/animal/day)	0.71
Material costs, US$		Labour costs, US$	50.0
Seeds	30.0	Cost of urea, minerals etc. US$	11.3
Fertilizers	17.6	Other costs, US$	
Herbicide	45.9	Feed costs , US$	78.0
Insecticide	3.1	Administration (10% gross inputs)	36.9
Other costs, US$		Interest (8%)	90.6
Rent of land	58.6	Gross input, US$	369.0
Administration	335.3	Profitability %	38.0
Interest on capital (8%)	63.6		
Gross input	3353. 4		
Profitability, %	290.0		

References

Brioso de Leon A 1979 Fertilizacion de un sistema de produccion de cultivos con granos y raices en una distribucion de precipitacion con un periodo seco corto Tesis Magister Scientiae Costa Rica URC - CATIE
Campion J E 1973 El uso de altos niveles de melaza con tres diferentes proteinas pare el crecimiento de toretes Agro (Republica Dominicanan) 11: 25-33
Clavo N 1974 Respuesta a diferentes niveles de urea por novillos alimentados con melaza y bagazo de cane de azucar Tesis Magister Scientiae Turrialba Costa Rica IICA 45 p
Conrad H R, Pratt A D & Hibbs J W 1964 Regulation of feed intake in dairy cows 1 Change in importance of physical and physiological factors with increasing digestibility Journal of Dairy Science 47: 54-62
Darlow A E, Ross O B, Stephens D F MacVicar R W, Cross F B & Thompson C P 1950 Dried sweet potatoes as a replacement for corn in fattening beef cattle 0klahoma Agricultural experiment Station Bulletin B-342: 5-15
Ffoulkes D, Hovell,F D Deb & Preston T R 1978 Sweet potato forage as cattle feed: voluntary intake and digestibility of mixtures of sweet potato forage and sugar cane Tropical Animal Production 3:140-144
Grainger R D, Oberlas D, Baker F H & Stroud J W 1960 A biological evaluation of urea with mature wethers Journal of Animal Science 19:1263 (abs)
Herrera E & Ruiz H E 1976 Fattening cattle with by products of sugar cane: 3 Substitution of final molasses by bananas Tropical Animal Production 1.53 (abs)
Jennings Jr B F, Thomason J H & Henderson H B 1948 Sweet potato meal vs ground corn in the ration of dairy cows Journal of Dairy Science 31: 341-346
Jones G M 1972 Chemical factors and their relations to feed intake regulation in ruminants A review Canadian Journal of Animal Science 52 207-239
Lush R E 1936 Sweet potato versus silage for milk production Journal of Dairy Science 19:460 (abs)
Massey Z A, Denney W W 6 Southwell B L 1976 Sweet potato meal in the ration for dairy cows Georgia Experimental Station Circular 156 4 p
Mather R E, Linkous W a & Eheart J F 1948 Dehydrated sweet potatoes as a concentrate feed for dairy cattle Journal of Dairy Science 31:569 - 578
McDowell L R, Conrad J H, Thomas J E & Harris L E 1974 Tablas de composicion de Alimentos de America Latina Gainesville Universidad de Florida 509 p
Montaldo A 1972 Cultivo de raices y tubercoles tropicalse Lima Peru insituto Interamericano de Ciencias Agricolas de la OEA 248p
Montgomery M J & Baumgardt B R 1965 Regulation of feed intake in ruminants I Pelleted ration varying in energy concentration Journal of Dairy Science 48:569-574
Mora Vargas C E 1969 Pruebas de produccion y calidad de variedades de camote en la zona intermedia alta del valle central Tesis Ingeniero Agronono San Jose Universidad de Costa Rica 48 p
National Research Council 1976 Nutrient requirements of domestic animals 4 Nutrient requirements of beef cattle 5th et Washington National Academy of Science 56 p
Oltjan R R & Putnam P A 1966 Plasma amino acids and nitrogen retention by steers fed purified diets containing urea or isolated soy protein Journal of Nutrition 89:385-391
Pinchinat A H 1970 Rendiaiento potencial del camote en la zone de Turrialba Tropical Root and Tuber Crops Newsletter 7:10-14
Ruiz M E, Pezo D 6 Martinez L 1980 The use of sweet potato (Ipomoea batatas, (L)) in animal feeling 1 Agronomic Aspects Tropical Animal Production 5: 144-151
Schwartz H H. Schoeman C A & Farber M S 5 1964 Utilization of urea by sheep 1 Rates of breakdownn of urea and carbohydrates in vivo and in vitro Journal of 4 Agricultural Science 63:289-296
Styler L L, Kern D L, Weaver V M & Oltjen R R 1971 Influence of starch and nitrogen sources on ruminal micro organisms of steers fed high fiber purified diets Journal of Nutrition 101:847-854
Tilley J M A 6 Terry R A 1963 A two-stage technique for the in vitro digestion forage crops Journal of the British Grassland Society 18:104-111
White T W, Reynolds W L & Hembry F G 1973 Influence of urea and molasses on nutrient digestibility of high roughage rations by steers Journal of Animal Science 37:1428-1432
Zumbado A Z 1967 Rendimiento y calidad e incidencia de Astura elevalis y otra insectos en camote cosechado en varies epocas Tesis Ingeniero Agronomo San Jose Universidad de Costa Rica 39 p

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