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THE ECONOMICS AND PUBLIC ACCEPTANCE OF CASSAVA BASED RATIONS IN THAILAND[1]

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This paper presents an evaluation of the economic viability and public acceptance of cassava based livestock rations. Data on the market prices of importnat feedstuffs and on biological responses from 15 feeding trials including some 3320 broilers, 1600 replacement birds, 768 layers and 182 growing-finishing pigs are analysed to evaluate the economical feasibility of cassava-based rations. It was found that cassava could be technically substituted for cereals only when the cassava price was lower than 50% of the cereal price. In the EEC, however, such economic substitution was possible when the cassava/maize price ratio was lower than 75%. Public acceptance of cassava-based rations in Thailand is still low. This is because cassava has been uneconomic to use, there have been wide fluctuations in the market price and irregular supplies of root products and stiff competition among feedmillers has prevented them from using cassava products into their compound feeds.

Key Words: Cassava, Thailand, economic evaluation, public acceptance

Cassava (*Manihot* spp) is an all season root crop grown widely in the humid tropics of South and Central America, Africa and Asia. Annual world production of roots is over 120 million tonnes of which 21% is harvested in Brazil, 11% in Thailand and 10% each in Indonesia and Zaire. As well as being a major staple human food in several regions, it is also an important substitute for feed grains in livestock rations. The use of cassava as a livestock feed has increased phenomenally in the last few years. The most important users of cassava feed are the European Economic Community (EEC) member countries particularly the Netherlands and West Germany. On the other hand, Thailand is the largest exporter supplying over 80% of the market demand or approximately 5-6 million tonnes each year. These exports constitute over 90% of total production, and consequently, the economy of Thai cassava producers is totally dependent on the export market, not domestic consumption. This is a major point of concern because the crop is so important to the country that the national economy will certainly be adversely affected if export levels are reduced. For these reasons, the Khon Kaen

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University team, with support from IDRC, launched a research program to evaluate the substitutional value of cassava feeds for cereals in livestock and the economic viability of such substitution under practical conditions.

Production and nutritive value of Thai cassava feeds: The conventional feedstuffs produced from Thai cassava are: cassava root chips, cassava root pellets and waste meal or pomace. Root chip production involves simple mechanical cutting, slicing or shredding (Thanh et al 1979). The chipped roots are then spread on a concrete floor (10-15 kg/m^2) and sun-dried for 1-2 days. Therefore, climatic factors and the shape and size of the chip naturally affect the rate of drying and ultimately the nutritive value of the dried product. The dry chip is normally pelleted (pellet 0.5 - 0.8 cm diameter, 2 cm long), which causes a 25 - 40% reduction in volume, eases handling and eliminates dust during transportation. Cassava waste meal or pomace is the residual pulp yielded from starch manufacturing. The dry pomace is a brownish colour and contains approximately 24% crude fiber and 55-70% nitrogen-free extract.

As with other tropical root crops, cassava roots contain a high level of carbohydrate and relatively low levels of fat, crude protein, minerals and vitamins (Table 1). The carbohydrate portion is primarily nitrogen-free extract (NEE), 80% of which is starch while the remainder is sugars and amides (Vogt 1966). It is therefore easily digested by all species of animals and is a good energy source in livestock and poultry rations. However, the energy value varies widely depending on age of the root, the method of processing and the species, age and condition of the tested animals. Muller et al (1975) reported the metabolizable energy (ME) levels of cassava root products in Singapore to be 3.8 Mcal/kg for pig, 3.65 Mcal/kg for poultry and 3.25 Mcal/kg for cattle.

One of the biggest disadvantages of substituting cassava for cereals in an economic ration is the low protein content of the cassava. Root products contain approximately 2.5% crude protein (Table 1); therefore, to maintain an equivalent crude protein level about 7 to 8% more protein must be added from more expensive sources such as soyabean meal or fishmeal. The economic viability of using root products in a least cost ration is thus heavily dependent on the price of other feed sources, particularly the substituted cereals and the supplemental protein sources. In addition, the amino acid make-up of a cassava-based ration must be carefully balanced because sulfur-containing amino acids are generally deficient (Hutagalung et al 1973; Maner 1973). These amino acids therefore must be supplemented in cassava-soyabean meal rations for the nonruminants. In addition, sulfur-containing amino acids must also be added for detoxification of hydrocyanic acid (HCN), the toxic substance found in cassava products (Enriquez and Ross 1967; Anomymous 1972; Hew and Hutagalung 1972; Maner and Gomez 1973; Oke 1973 and Wheeler et al 1975). Cassava root products are also deficient in fat and essential fatty acids (Hudson and Ogusua 1974), minerals with the exception of calcium from contaminating soil (Khajarern et al 1979b), and vitamins with the exception of ascorbic acid (Oyenuga 1968). These nutrients must therefore be supplemented to produce balanced livestock rations Special attention must be paid to essential fatty acids (Ng and Hutagalung 1974), zinc (Maust et al 1969), iodine (Ermans et al 1973) and vitamin B12 (Oke 1973).

In addition, it has been generally acknowledged that rations containing high levels of cassava root products are less palatable than the cereal based rations. This is mainly due to their dry, loose, powdery texture and their bulk (Chou and Muller 1972; Palisse and Barratow 1974; Muller et al 1975; Khajarern and Khajarern 1977). This disadvantage can be partially remedied by pelleting the diet (Muller et al 1975), supplementing with fat to reduce the dust (Ng and Hutagalung 1974; Hutagalung 1977) and by paste feeding (Khajarern et al 1979b). By combining this information with biological tests Khajarern et al (1979a) produced a hypothetical cassava-soy bean meal mixture that could be totally substituted for maize in livestock rations. This mixture (Table 1)is used as the basis for the subsequent economic evaluation.

Table 1:
Chemical composition (%) and ME (kcal/kg) of cassava root meal in comparison with maize meal and a meal made of a mixture of 80% cassava, 15% soyabean meal and 5% fat

Components	Cassava	Maize	Mixture
Moisture	12.10	13.50	11.78
Crude protein	2.50	8.50	8.88
Ether extract	0.30	3.80	5.39
Crude fibre	3.50	2.00	3.64
Ash	1.80	1.10	2.40
NFE	79.80	71.10	72.91
Calcium	0.18	0.03	0.20
Phosphorus	0.09	0.27	0.18
Lysine	0.042	0.250	0.473
Methionine and cystine	0.019	0.260	0.226
Threonine	0.055	0.350	0.332
Tryptophan	0.011	0.050	0.099
ME, kcal/kg			
Pig	3,800	3,810	3,810
Poultry	3,650	3,660	3,625
Cattle	3,250	3,290	3,483

Sources : Muller et al (1975) and Khajarern et al (1979a).

Economic considerations of cassava-based rations: The first reports on the substitution of cassava for cereals in the rations appeared for poultry in 1935 (Tobayayong 1935) for pigs in 1941 (Raymond et al 1941) and for dairy cattle in 1919 (Henke 1919). Since then, continuous attempts have been made to evaluate its nutritive value and its effects on animals. At present, some Western European governments such as West Germany and the Netherland have officially acknowledged its use and established official controls on the maximum level of substitution (Seerly 1972). The latest levels used by the European Feed Manufacturers' Association (FEFAC) are: 5% cassava meal for dairy concentrates; 30-35% for pig feeds; and 12-15% for poultry rations of cassava in rations are very much dependent on kind, age and productive purpose of the animals. In terms of research, it may have been because of the increasing competition for cereals between man and his animals that nutritional studies were geared to obtaining the maximum substitution of cereals by cassava products. This has been spearheaded by work at CIAT, Colombia (Anonymous 1972, 1973, 1974, 1975; Gómez 1977) and followed by those in Venezuela (Montaldo and Montilla 1976; Montaldo 1977) Malaysia (Hew and Hutagalung 1977; Devendra and Hew 1977), Singapore(Muller et al 1975) and others. At Khon Kaen University, Thailand, we have done similar work since 1975. Based on this research it can be concluded that:

1) Cassava root products can be totally substituted for maize and other cereals in rations for all classes of livestock and poultry. However, special care must be paid to diet formulation: micronutrients, in particular sulfur-containing amino acids and vitamin B_{12}, must be balanced; crude fibre ash and calcium must be kept as low as possible and adequate supplies of phosphorus, zinc and iodine must be provided.

2) Diets containing high levels of cassava must be fed in forms that support optimal feed intake.

3) Cassava-based diets for poultry must be supplemented with fishmeal or synthetic xanthophylls to maintain normal pigmentation of the skin or egg yolk.

4) Under these conditions, the maximum levels of cassava that have been successfully incorporated into livestock and poultry rations at Kohn Kaen University are given in Table 2.

Table 2:
Maximum levels of cassava root products successfully incorporated in livestock and poultry rations at Khon Kaen University

	Maximum level of cassava in rations designed for specific growth period				
	Starter	Grower	Finisher	Replacement Bird	Layer
Broiler	58.0	-	58.0	-	-
Replacement layer	40.0	60.0	-	60.0	-
Layer	-	-	-	-	50.0
Pig	50.0	60.0	70.0	-	-
Beef cattle	-	-	60.0	-	-

One additional conclusion that could be added is that the economics of such substitution must be examined under practical conditions. As stated previously, the economics of the substitution is dependent on the price structure of the cassava products, the replaced cereals, and supplemental sources for protein and other nutrients. Of course, the price structure of these feedstuffs fluctuates widely with demand and supply, which are directly influenced by season or period of the year, location and their availability at the time they are needed.

To evaluate the economic viability of cassava-based livestock and poultry rations under practical condition, we have analysed the substitutional pattern, price structures and biological responses based on our studies at Kohn Kaen University. Table 3 presents the average price of selected feed ingredients and some price ratios in Bangkok and in other importing ports during the course of the study. The data show two distinct features: (1) The price ratio of cassava pellets to maize in Thailand has been quite stable for the last 5 years (0.67-0.84) whereas in the importing countries it has fluctuated widely (0.52-0.88) although, on average, it has been lower ((0.71 vs 0.77) in Thailand; and (2) the price of locally produced soybean meal in Thailand is (relatively) more expensive than soyabean imported into the EEC. This clearly indicates that the economic feasibility of substituting cassava products for cereals in livestock rations is higher

Table 3:
Comparisons of price of some selected feed ingredients and price ratios for cassava/maize (CP/M) and soyabean meal/maize in Bangkok and foreign ports US$/ton

Ingredients	Year				
	1976	1977	1978	1979	1980
Bangkok					
Cassava pellet (CP)	85.94	78.16	70.85	122.07	120.70
Maize (M)	107.77	105.57	105.13	155.27	144.34
Soyabean meal (SBM)	263.13	338.77	320.39	331.05	356.38
Price ratio: CP/M,%	79.74	74.04	67.39	78.62	83.62
SBM/M	2.44	3.21	3.05	2.13	2.47
Foreign Ports					
Cassava pellet, C.I.F. Rotterdam	115.97	103.78	102.18	166.88	130.44
Maize, US.No.3, C.I.F. Tilbury	132.41	145.78	196.18	205.11	214.50
Soyabean meal, C.I.F. UK.	224.24	259.80	234.57	242.29	264.13
Price ratio: CP/M,%	87.58	71.19	52.08	81.36	60.87
SBM/M	1.69	1.78	1.20	1.18	1.23

Source: Board of Trade Bulletin, Board of Trade, Rajbopit Road, Bangkok, Thailand, 1976 - 1980.

in the EEC than in Thailand. The highest possible prices for cassava pellets that would allow economic substitution for cereals have been estimated for both markets (Table 4). In Thailand the export demand increases the cassava price above the level at which economic substitution for cereals can take place. Simultaneously, the actual market price of cassava in the EEC has continued to be far lower than the economic threshold that allows root products to be selected in least cost rations. This phenomenon is understandable because the Common Agricultural Policy of the EEC artificially increases the price of cereals and, at the same time, increases the economic possibility for cassava utilization. In Thailand, however, locally produced feedgrains are quite cheap and do not allow economic substitution by cassava. Under the price structure for the major feed ingredients that has existed for the last 5 years, the economic substitution of cassava root products for cereals in livestock rations in Thailand will be possible only when the price of cassava products is less than 50% of the price of cereals; whereas, such substitution in the EEC is possible when the price ratio is about 75%.

Table 4:
Maximum price (US$/ton) of cassava pellets for economic substitution for maize in a least cost ration, Bangkok and the EEC[1] (selected years)

Price	Year					
	1976	1977	1978	1979	1980	Mean
Bangkok						
Actual	85.94	78.16	70.85	122.07	120.70	95.54
Maximum Price	61.80	45.36	48.34	98.05	82.04	67.12
Maize	107.77	105.57	105.13	155.27	144.34	123.62
Maximum, % of maize price	57.30	42.96	45.98	63.15	56.84	53.25
EEC[2]						
Actual	115.97	103.78	102.18	166.88	130.44	123.85
Maximum Price	94.51	101.63	158.32	166.09	171.68	138.45
Maize	132.41	145.78	196.18	205.11	214.50	178.80
Maximum, % of maize price	71.37	69.71	80.70	80.98	80.03	76.56

1 Assumptions: a. Substitutional equation 0.80CP+0.15SBM+0.05Fat = 1.00Maize
b. Price of feed grade fat = 3.5 x price of maize
c. Prices of main feed ingredients are as shown in Table 3

2 Prices are based on C.I.F. Rotterdam.

Despite of the fact that this hypothetical analysis indicates low economic viability of cassava-based rations under Thailand's price structure, biological tests with livestock and poultry (4 trials on 3320 broiler chicks, 2 trials on 1600 replacement layers chicks, 2 trials on 768 layer hens and 7 trials on 182 pigs) have demonstrated economic gains (Table 5-9).

Table 5:
Growth performance of broilers being reared on diets containing various levels of cassava root products[1]

Performance	Level of cassava, % of ration				C.V. (%)
	0	20	40	60	
Trial 1 (9 weeks)[2]					
Average weight gain,g [3]	1,768	1,793	1,701	-	5.13
Feed/gain [4]	2.68	2.68	2.76	-	3.03
Feed cost/kg gain,Bht. [4]	14.67	11.28	11.31	-	3.17
Trial 2 (8 weeks) [5]					
Average weight gain,g	1,479	1,501	1,505	1,487	3.89
Feed/gain [3]	2.23	2.22	2.28	2.27	3.52
Feed cost/kg gain,Bht. [3]	10.35	9.97	9.82	9.02	3.66
Trial 3 (9 weeks) [5]					
Average weight gain,g [6]	1,614	1,773	1,714	1,731	3.41
Feed/gain [3 6]	2.92	2.55	2.67	2.67	3.24
Feed cost/kg gain,Bht. [3 6]	14.17	11.86	11.81	10.96	3.17
Trial 4 (8 weeks) [7]					
Average weight gain,g	2,121	1,942	1,988	1,983	3.88
Feed/gain	2.26	2.37	2.36	2.44	1.85
Feed cost/kg gain,Bht. [3]	11.28	12.16	12.41	12.98	1.88

1 US$ 1.0 = Bht. 20.35

2 Each figure represents the mean of 100 birds being fed mash diets

3 Lin.$P < 0.05$

4 Lin.$P < 0.01$

5 Each figure represents the mean of 200 birds being fed pellet cassava diets

6 Quad.$P < 0.01$

7 Each figure represents the mean of 80 birds being fed pellet cassava diets

In most trials, the economic gain has been realized at somewhat lower production levels or by using semi-commercial type rations. These optimistic responses may be partially explained by the following:

1) The suboptimum response of the control groups strongly indicates the inferior quality of conventional feedstuffs. In Thailand, feed quality control regulations are not rigurously inforced, and consequently, the feedstuffs available to small buyers are often of low quality. This naturally lowers the plane of nutrition and increases the possibility of economic substitution of low quality cereals by cassava products. Once the possibility of incorporation of inferior feedstuffs was cut down as demonstrated in the semi-commercial type of diets in pig experiments (Trials 4 to 7 in Table 9), one can see that both types of diets supported comparable growth performance and the economical loss experienced in cassava groups of trials 6 and 7. This tendency is more pronounced if one compared the cassava group to the control pigs being fed the commercial compounded ration. This

Table 6:
Growth performance of replacement layers being reared on diets containing various levels of cassava root products[1]

Performance	Level of cassava, % of ration S-G-R 0-0-0	S-G-R 40-60-60	C.V, (%)
Trial 1 (19 weeks)			
Body weight,g	1,571[a]	1,645[b]	-
Feed/gain	4.86[a]	4.43[b]	-
Feed cost/pullet,Bht.	25.69	22.42	-
Trial 2 (20 weeks)			
Body weight,g	1,823	1,766	1.4
Feed/gain	4.29	4.51	2.4
Feed cost/pullet,Bht.	29.55	28.86	-

1 Each figure represents the mean of 400 birds being fed pellet diets.

again shows that a large buyer, such as a feedmill, always has a better chance to control the quality of the incoming feed ingredients than does a small buyer. Under better controlled conditions, cassava can therefore be a good substitute for cereals in an economic ration and the economic viability of its substitution tends to follow the presented hypothetical analysis.

Table 7:
Hen-day production of layers being reared on diets containing various levels of cassava root products[1]

	Cassava level, % of ration				C.V.(%)
Cassava levels for S-G-R	0-0-0		40-60-60		
Cassava levels for layer	0	50	0	50	
Trial 1 (40 weeks)					
Hen-day production,% [2]	64.2	58.7	64.9	59.1	5.2
Trial 2 (40 weeks)					
Hen-day production,%	50.59	-	-	50.29	7.2

1 Each figure represents the mean of 96 hens being fed pellet diets.

2 Effect of cassava level in laying rations is significant at $P < 0.05$.

Table 8:
Growth performance of G-F pigs being reared on pellet diets containing various levels of cassava root products[1]

Performance	Level of cassava, % of S-G-F ration			C.V. (%)
	0-0-0	30-40-60	50-70-70	
Trial 1 [2]				
Average daily gain, kg	0.436[a]	0.498[b]	0.464[ab]	5.86
Feed/gain	3.21	3.13	3.15	6.72
Feed cost/kg gain, Bht	10.21	10.06	9.69	5.00
Trial 2 [2]				
Average daily gain, kg	0.516	0.524	0.509	8.43
Feed/gain	3.46	3.64	3.51	4.07
Feed cost/kg gain, Bht.	11.76	12.01	11.27	9.04
Trial 3 [3]				
Average daily gain, kg	0.540	0.509	0.534	5.00
Feed/gain	3.62	3.45	3.42	3.08
Feed cost/kg gain, Bht.	14.39[b]	12.65[a]	12.35[a]	5.01

1 The means within the same row bearing different superscripts differ significantly at $P < 0.05$.

2 Each figure represents the mean of 15 pigs.

3 Each figure represents the mean of 9 pigs.

2) The protein supplements used in these trials were made up of about half animal protein from fishmeal and half from soyabean meal. In addition to providing better protein quality than in the hypothetical analysis, this also lowers the amount of soyabean meal that must be added to the rations and thus lowers the feed cost. In addition, the cassava - soyabean meal-fishmeal based rations are less deficient in certain critical nutrients, in particular methionine, vitamin B_{12}, and phosphorus. Consequently supplementation of high quality protein from fishmeal will ease the dependence of cassava-based rations on imported nutrients, allow a cheaper equivalent ration to be produced, and thus increase the possibility of economic substitution of cassava for cereals. The need for such a high quality protein source in diets based on high levels of cassava has generally been acknowledged (Maner and Gomez 1973; Hew and Hutagalung 1977).

3) In the presented trials, fat (tallow) was added to the cassava diet at levels lower than those proposed in the hypothetical case. The actual levels ranged from 0 to 4.1%, which contributed to a lower feed cost per unit of weight gain, but did not significantly reduce the response of animals receiving energy levels near the optimum.

Table 9:
Growth performance of G-F pigs being reared on semi-commercial diets basing on total substitution of cassava for cereals[1]

Performance	Levels of cassava, % of S-G-F ration			C.V. (%)
	Comm. Control	0-0-0	50-70-70	
Trial 4 [2]				
Average daily gain, kg	0.664[c]	0.447[a]	0.568[b]	7.13
Feed/gain	2.81[a]	3.51[b]	3.13[a]	5.36
Feed cost/kg gain, Bht.	11.56[a]	15.44[b]	12.89[a]	4.89
Trial 5[3]				
Average daily gain, kg	-	0.338[a]	0.737[b]	13.76
Feed/gain	-	4.17	3.00	10.75
Feed cost/kg gain, Bht.	-	15.58	12.67	10.04
Trial 6 [4]				
Average daily gain, kg	-	0.669	0.647	4.75
Feed/gain	-	3.31	3.56	3.99
Feed cost/kg gain, Bht.	-	12.20	13.76	3.76
Trial 7 [5]				
Average daily gain, kg	-	0.548	0.561	16.03
Feed/gain	-	3.70	3.61	15.59
Feed cost/kg gain, Bht.	-	13.08[b]	14.53[a]	14.27

1 The means within the same row bearing different superscripts differ significantly at $P < 0.05$.
2 Each figure represents the mean of 9 pigs.
3 Each figure represents the mean of 8 pigs.
4 Each figure represents the mean of 8 pigs.
5 Each figure represents the mean of 8 pigs.

4) All cassava-based diets (except Trial 1, Table 5) were pelleted to equalize feed intake with the cereal controls. The heat generated during pelleting renders the feed more digestible and thus makes the nutrients more available than in the unpelleted feed (Mercier and Guilbot 1974). This likely makes the cassava-based diets more digestible than the cereal controls as shown by the better growth performance and economic gains of the cassava groups.

Public acceptance of cassava-based rations in Thailand: An important point when considering economic substitution of cassava for cereals in livestock rations in a developing country like Thailand is the supply of micronutrients. Thailand imports essentially all the feed additives and micronutrients, such as amino acids, vitamins and trace minerals, required for feed manufacturing. Cassava-based diets require a higher supplementation of these ingredients than cereal diets. Therefore the economic viabily ty of such substitution will be limited by the high price of these imported

Table 10:
Mean, standard deviation and coefficients of variation of some selected feedstuffs in Bangkok during 1977 to 1979

Ingredients	Mean ± S.D. (Bht/kg)	C.V. (%)
Broken rice	3.12 ± 0.20	6.50
Rice bran	3.16 ± 0.34	10.73
Ground maize	2.72 ± 0.47	17.36
Fresh cassava root	0.53 ± 0.18	34.71
Cassava pellet	1.77 ± 0.54	30.74
Soyabean meal	6.59 ± 0.35	5.27
Fish meal	8.34 ± 0.52	6.26

Source : Chayaputi et al.(1980).

ty of such substitution will be limited by the high price of these imported products. The chance of economic substitution may be slightly higher for livestock requiring a lower plane of nutrition or offering lower production levels. Public acceptance of such substitution is therefore dependent on the philosophy of each producer. Montilla (1977) expressed his belief that even with a deterioration of 10% in production, diets based on cassava products were still economically feasible in developing countries.

In Thailand, these considerations have not been realized. The philosophy of production is still aimed at maximum production at any cost. The technology available for feed compounding is quite advanced, and least cost formulation are used in almost all feedmills. However, it is only in the last 2 or 3 years that cassava products have been included in the list of feedstuffs. Some feedmills have now started to include cassava at maximum levels of 12-30% of the rations depending on the species and productive purposes of the livestock. Even if the computer selects cassava in the least cost ration some formulators reduce its level to protect their position in the market because they are hesitant to make such a change in their routine formulation. Chayaputi et al (1980) evaluated public acceptance of cassava-based rations and concluded it was low because:

1) The price of cassava products did not allow its economic substitution for cereals in any diets, and in addition, price and supply were irregular and fluctuated widely with export demand as indicated in Table 10; and

2) the nutritionists at most feedmills were skeptical about the nutritive quality of the products and worried about possible subclinical HCN toxicity in cassava-based diets.

This skepticism seems unreasonable because Thailand exports cassava products as feedstuffs to the EEC and such adverse effects have not been a problem. Their main reason for not replacing cereals with cassava is the fact that they cannot change their customers' beliefs that cassava products in the diets would produce various adverse effects. Competitors would not hesitate to publicize the fact that a feedmills was performing such substitution. Therefore, it is the duty of the government organizations and institutions to demonstrate to the livestock and poultry producers that scientific feeding trials with cassava-based and cereal-based rations have produced comparable results. Once the producers gain confidence in cassava-based rations, the problem on low public acceptance of the rations will be resolved.

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