Cassava Root and Foliage Within a Program for Poultry and Swine Feeding in the Tropics

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From the dawn of the earliest civilizations, man has used different animal species for the production of high quality foods, under the common sources of animal protein. Logically, the tendency is to produce with the most efficient species, and to provide the most effective means of production. The production of hen eggs and milk (from high production cows) figure among the most efficient processes in the conversion of both crude protein and energy for the production of food edible to man; equally efficient are broilers as protein converters, but these convert energy in a manner more or less the same as that of pigs, which occupy an intermediate position between the egg-producing hen and the dairy cow on the one hand, and cattle and sheep as meat producers on the other (Fig. 1).

In tropical countries, with the exception of certain microclimates, the exploitation of existing strains of high production dairy cattle is seriously limited by problems related to the adaptation of these animals to the environment. On the other hand, poultry and pigs adapt quite well to a wide range of climate conditions, in a manner by which it can be affirmed that their exploitation can be carried out in an effective and economically viable way in all areas of the world inhabited by man.

During the last four decades, there was an exceptional increase in the productive capacity of poultry and pigs arising from the progress made by science in a number of areas: Genetics, animal health and hygiene, management, and nutrition. It can be affirmed that at present, any country in the world can, without the need for heavy investments, count on the availability of genetically sound avian and porcine material, effective methods for the control of pests and dieasess, and adequate management systems which permit the necessary degree of comfort suitable for optimal yields; unfortunately the same is not true with the nutrition of these species. The development of avian and porcine production is one of the ways in which the developed countries of the western world and, to a certain extent, the socialist countries, transform their agricultural excess into more appetizing products of exceptional nutritional value to the human population. In the developing countries, these excesses do not exist; on the contrary, there is a deficit with respect to vegetable foodstuffs for human nutrition. The creation of a vegetable-based agriculture in excess, is an indispensable prerequisite for self-sufficiency to an effective animal production activity in tropical areas.

The purpose of this paper is to formulate a scheme for vegetable production in the tropics to support poultry and swine production capable of achieving, by 1985, an annual *per capita* consumption of poultry and pig products similar to the current world average of 5.70 kg of poultry meat, 5.90 kg of eggs and 10.70 kg of pork (FAO, 1978).

As may be seen in Tables 1 and 2, the production and productive capacity of poultry and pigs are extremely inferior in the developing market economies in comparison with the developed market economies and to a lesser extent with those of the central planned economies. This, in turn, leads to an unequal annual *per capita* supply of poultry products (egg and poultry meat): 33.30 Kg in the developed market economies, 12.1 kg in the central planned economies, 3.85 Kg in the developing market economies, and with an average world consumption of 11.6 Kg. In the same way, the consumption of pork is 25.2 kg. 16.0 kg, 1.8 kg. and 10.7 kg respectively. A similar disparity is observed in the supply of other sources of animal protein (Table 3).

Cereals, roots and tubercles represent 72.9% expressed in metric tons (mt) of the world production, of vegetable foodstuffs. The developing countries inhabited by 49.11% of the world population (Table 4). produce only 29.3% of the cereals and 31.7% of the roots and tubercles, leading exclusviely in the production of relativelv low value crops within the world total (Table 5). This situation is aggravated because a large proportion of the vegetable production achieved is not destined for internal consumption but for export to the developed countries. Logically, and as a result of a deficient vegetable production (Tables 6, 7, 8 and 9), the animal production achieved in the tropics is clearly inferior to that of the developed countries situated in temperate areas (Table 10).

The disparity in the animal and vegetable productivity between tropical and **temperate areas seems to be due to the first areas insisting cultivation of crops which are not effectively produced within their ecosystem.**

With sugar cane *(Saccharum officinarum)* and cassava *(Manihot esculenta)* production figures superior to 30 million kilo calories/hectare (kc/ha), are achieved in the tropics when suitable varieties and methods of cultivation are utilized, whereas cereals produce only 6 million kc/ha; however 3.3% (20.4 million ha) of the cultivable areas of the tropics are dedicated to the cultivation of sugar cane and cassava, while 44.3% (289.6 million ha) are given to the production of cereals (Montilla, 1975).

Green plants represent the most abundant and economical source of proteins as a result of the synthesis of amino acids through photosynthesis from primary elements available in almost unlimited quantities: Solar energy, carbon dioxide, water, and inorganic nitrogen (Oke, 1973). This fact is of relevant importance in the tropics, where vegetable production is possible throughout the whole year. The aerial part of the cassava plant seems to be one of the best alternatives for the production of leaf proteins, since crop yields in excess of 5 mt of protein *per annum* can be achieved when the productive activity is devoted exclusively to the crop (Meyreles and Macleod, 1976, Montilla, 1977). Eggum (1970) reports that cassava leaf protein is deficient only in methionine, and when supplemented with this amino acid, its biological value increases from 48.8% to 80.4%, and the utilizable nitrogen increases from 2.04% to 3.20%.

Certain seed legumes constitute another possibility for the production of proteins in the tropics for the feeding of poultry and pigs; among these figure the so called "jack bean" (*Cannavalia ensiformis*). With reference to this plant, Rachie (1975) reports seed yields of 2.696 kg/ha on observations carried out in Nigeria. The FAO (1959) reports yields of between 1000-4000 kg/ha in the former Belgian Congo. The seed of *Cannavalia ensiformis* contains around 29% protein and 6% fiber.

Table 11 presents the production/ha considered possible in the tropics under appropriate ecological conditions and using good agricultural methods for the various types of cultivations used and applicable as sources of raw material for the feeding of poultry and pigs.

Sufficient physiological and economic evidence is available to demonstrate the feasibility of utilizing cassava root flour in feeds for poultry in substitution for cereals. An analysis of the pertinent literature shows that the product can be incorporated into broiler diets at levels higher than 30% (Enriquez and Ross, 1967; Montilla *et al.*, 1969);

Olson *et al.,* 1969; Montilla *et al.,* 1970; Armas and Chicco, 1973, and Montilla *et al.,* 1975) and completely substituting cereals in feeds for laying hens (Enriquez and Ross, 1972; Montilla *et al.,* 1973[a] and Portal *et al.,* 1977) without affecting the productive capacity of the birds.

Sugarcane molasses satisfactorily substitute 15% of cereals in broiler feeds (Montilla *et al.,* 1973[b] and Montilla and Weidenhofer, 1975) and information exist which indicates that 10% is compatible with the maximum production in laying hen feeds (Angulo *et al.,* 1974).

The papers by Perez *et al.* (1968) and Perez and Preston (1970) show that first sugar cane molasses is an excellent source of carbohydrates for broilers even when it completely substitutes cereals. Similar results are reported by Perez (1967) when this product is incorporated in laying hen feeds at a 24% level.

According to Benitez *et al.* (1968), refined sugar can be utilized up to a level of 30% in the broiler rations without interfering with the productive capactiy; higher levels (40%) can also be utilized, but extra supplementation with vitamin B compelx is required. Similar results are reported by Ramon *et al* (1968), in the case of laying hens.

Ross and Enriquez (1969), on adding up to 20% cassava leaf flour to feed for Leghorn chicks, found a deterioration in the weight gain and feed efficiency as from a 5% level, effects which were corrected when the feeds were supplemented with methionine at levels of 0.15 – 0.20% and with the addition of 3% maize oil. Mendes *et al* (1973), did not observe significant differences for weight increase and feed efficiency on incorporating 3%, 6% and 9% cassava leaf flour into broiler feeds.

Montilla (1977), affirms that although a certain deterioration occurs in weight gain and feed efficiency, the incorporation into broiler rations of 16% cassava foliage flour, prepared with material cut at 90 day intervals, results in body weights comparable to those obtained in commercial practice, and without appreciably modifying the costs. The same author reports that with the same level of cassava foliage flour, a saving of 23.6% oilseed flour/kg chicken produced is achieved.

Papers by Carabaño *et al* (1977) and Montilla *et al* (1977) indicate that at least two factors which interfere with the normal growth of chicks are present in the seeds of *Cannavalia ensiformis,* one of which is thermolabile and the other thermostable; however when the seed flour was autoclaved at 121°C for 90 minutes, its incorporation at a 10% level into chicken feeds did not affect either the weight gain or the feed efficiency. Further research must be carried out on the use of "jack bean" seeds in the nutrition of poultry and pigs.

The papers of Mejias (1960), Chicco *et al* (1972), Alvarez and Alvarado (1974), Gomez (1977), Manickam *et al* (1976) and Khajarern *et al* (1977) show that cassava root flour can substitute more than 70% of the cereals in feeds for the growth and fattening of pigs, without affecting their production behaviour; in the same way, high levels can be utilized with pigs during the period of gestation and lactation (Gomez, 1977).

Mahendranatan (1972) compared a basic feed for the growth of pigs with others in which 50% and 75% of the basic feed was replaced by cassava foliage tops harvested at 2-monthly intervals. The greatest weight increase corresponded to animals which consumed the feed containing 75% cassava foliage; at both levels the feed efficiency was adversely affected. Kok Choo and Hutalagung (1972), found that the incorporation of cassava leaf flour in pig feeds at levels of up to 20% decreased the growth rate, but to a large extent these adverse effects disappeared when the feeds were supplemented with palm oil and 0.2% methionine.

The papers of Shimada and Brambila (1966), Correa *et al* (1969), Preston *et al* (1968), Velasquez and Preston (1973), Boustond (1973) and Perez (1977), show that both first and final sugar cane molasses can be incorporated at levels higher than 50% in swine rations without any deterioration in the productive capacity or economic benefits.

Because of the high yield capacity of sugar cane, jack bean and cassava (for root and foliage production) and the results obtained when the products of these crops are incorporated in poultry and pig feeds, its massive utilization in the feeding of these species appears feasible.

Taking as a figure that in 1985 the annual *per capita* consumption of poultry meat, eggs and pig meat in the developing countries will reach 14.7 million mt of poultry meat, 14.9 million mt of eggs, and 26.1 million mt of pig meat respectively will be required by the 2477.8 million inhabitants of these countries (Table 12). The amounts of poultry and pig feeds required to achieve this production are given in Table 12 as much for classical feeds as for the proposed alternative.

With the latter, a certain deterioration can occur in the feed efficiency because the concentration of nutrients and energy in the feeds is decreased. The total amount of feeds required is therefore increased by 257.6 million mt. Assuming that 30% sugar cane first molasses (or a combination of this and final sugar cane molasses), 25% cassava root flour, 10% cassava foliage flour and 8% "jack bean" flour can be generally incorporated into feeds for poultry and pigs, totalling 73% of the ingredients of the feeds, the cultivation of 22.3 million ha will be necessary (Table 13), which when increased by 25% as a safety factor – will reach 27.9 million ha. With classical formulae, and taking into due consideration that rice, maize and sorghum are utilized in equal amounts and with the yields given in Table 11 and with the current yields/ha of oil seed flours, it will become necessary to cultivate approximately 68.5 million ha to achieve this same end which, using the same safety factors, will increase to 85.6 million ha.

The remaining 27% of the feeds will be made up with cereal by-products, small amounts of whole cereals, slaughter house by-products, fish meal, oilseed flours, other industrial by-products, minerals, vitamins, processed wastes(1), and poultry manure (these latter two for pigs only).

It is important to emphasize that in animal production in general, and more especially in the production of poultry and pigs, the evaluation of the feeding experiments must be carried out not only on the basis of weight gain and feed efficiency; the product obtained per hectare (mt/ha) must also be determined and this constitutes a more logical evaluation for agricultural activities. Countries located in temperate climates obtain between 1.5 – 2.0 mt/ha of poultry and pig products when cereals and soya flour are used as the principal feed components.

These levels of production can be achieved and even surpassed in the tropics via the massive utilization of cassava and other high yield tropical products. Presently, in the tropical areas of the world, only 0.4 mt of poultry and pig products/ha is achieved on the basis of the utilization of classical feeds.

A program as put forward here, would permit a substantial improvement in the protein consumption of the people of the developing countries. In these countries, at present, the consumption of meat, milk and eggs results in a mere 9.45 g protein/*per capita/per diem*, whereas the minimum requirement is 20 g (Catron and McRoberts, 1966).

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(1) This implies the utilization of wastes from restaurants, factory canteens, hospitals, schools and other centers where large numbers of people are fed.

The execution of this program would require, without doubt, copious investments not only to carry out a more technified agriculture, capable of producing yields of the order of those indicated in the present paper, and for the avian and porcine productions involved, but also for the processing of the vegetable products to be utilized. Its execution on a short or medium term basis will require the full collaboration of the developed countries, as a debt which is owed to those countries which have served as the source of their raw materials. In the event that this type of solidarity should fail to materialize, thought must be given to the possibility of a combined effort between all of the developing countries.

Conclusion

1. The production and productivity of poultry and pigs is uneven at a world level.

   a. In the western developed countries a figure of 1645.3 million chickens and hens produce 13.7 and 11.5 million mt of poultry meat and eggs, respectively; in the developing countries 1940.4 million birds produce only 3.4 and 3.8 million mt of the same products, and in the socialist countries 2530.8 million birds produce 6.1 and 8.6 mt of poultry meat and eggs respectively.

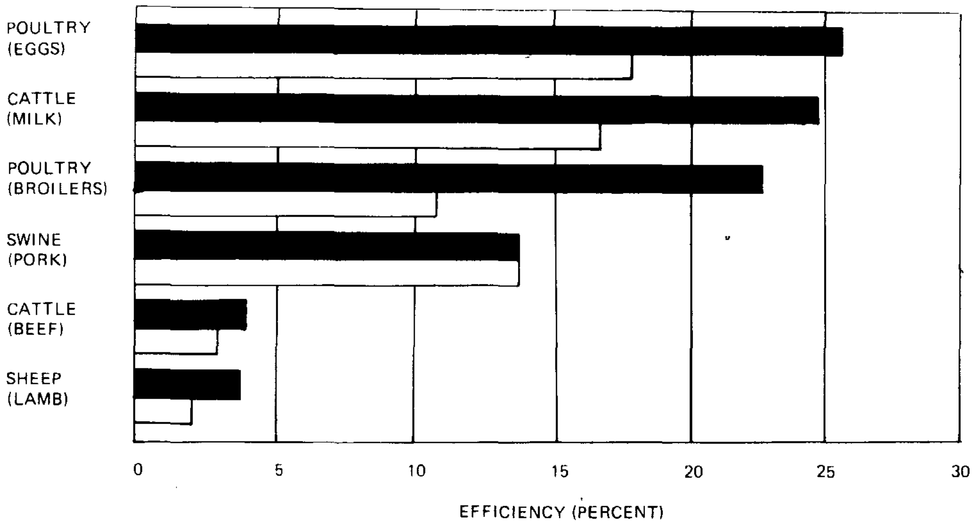
   b. Of 173.9, 114.8 and 377.6 million pigs existing in the western developed countries, the developing countries and the socialist countries respectively, 19.3, 3.6 and 20.9 million mt of pig meat are obtained in the areas.

2. The production of vegetables is also uneven. The developing countries inhabited by 49.4% of the human population produce only 29.3% of the cereals and 31.7% of the roots and tubercles, among the world total. These two groups of crops constitute 72.0% of the world production of vegetable food.

3. A type of tropical agriculture must be created to form the basis and sustain an effective animal production system.

4. Sugar cane *(Saccharum officinarum),* cassava (*Manihot esculenta)* and "jack bean" (*Cannavalia ensiformis*) appear to be crops with an excellent potential for poultry and pig nutrition in the tropics. The cultivation of 27.9 million ha with these plants would permit an annual increased *per capita* consumption of poultry and pig products of 5.7 kg poultry meat, 5.9 kg eggs and 10.7 kg pig meat in the developing countries.

Figure 1. Efficiency of livestock to convert protein and energy to produce edible to man



*Dark bars: protein
Clear bars: energy

Source: Janick *et al.*, 1976.

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Table 1. World production of poultry and eggs by group of countries (1976)

Group of Countries	Existence of Poultry (Head x 10^6)	Poultry Meat (MT x 10^6)	Eggs (MT x 10^6)	Per capita consumption Meat (kg.)	Eggs
World	6,116.4	23.1	23.8	5.7	5,9
Developed M.E.	1,645.3	13.7	11.5	17.9	15.1
Developing M.E.	1,940.3	3.4	3.8	1.7	1.9
Central planned	2,530.8	6.1	8.6	4.7	6.6

SOURCE: FAO 1978
Own calculations

Table 2. World pig meat production by group of countries

Group of Countries	Existence of Pigs (Head x 10^6)	Pig Meat (MT x 10^6)	Per Capita Consumption (kg.) Pig Meat
World	666.3	43.8	10.7
Developed M.E.	173.9	19.3	25.2
Developing M'E.	114.8	3.6	1.8
Central planned	377.6	20.9	16.0

SOURCE: FAO 1978
Own Calculations

Table 3. Annum per capita production of meat, milk and eggs by group of countries (Kg.)

Group of Countries	Total Meat	Beef Meat	Pig Meat	Poultry Meat	Other Meats	Milk	Eggs
World	30.7	11.3	10.7	5.7	3.93	99.6	5.9
Developed M.E.	79.5	31.5	25.2	17.9	4.70	277.2	15.1
Developing M.E.	11.7	5.7	1.8	1.7	2.35	28.30	1.9
Central Planned	31.6	8.0	16.0	4.7	2.50	106.20	6.6

SOURCE: F.A.O. 1978
Own Calculations

Table 4. World human population, total and by group of countries (X 10^6)

GROUP OF COUNTRIES	ACTUAL 1977	EXPECTED 1985*
World	4,103.3	4,704.4 (1)
Developed M.E.	767.3	810.9 (2)
Developing M.E.	2,028.7	2,477.8 (3)
Central Planned	1,307.3	1,415.7 (4)

*INTERANNUAL GROWTH RATE
(1) 1.9%
(2) 0.7%
(3) 2.6%
(4) 1.0%

SOURCE: F.A.O. 1978
Own Calculations

Table 5. World agricultural and livestock production 1976 (M.T. x 10^6)

Group of countries	Cereals	Root and tubers	Pulses	Vegetables	Fruits	Nuts	Vegetable Oils	Centrifugal Sugar	Meats	Milk	Eggs
World	1,477.4	558.0	51.5	311.8	261.4	3.7	41.0	86.4	121.7	433.0	23.8
Developed M.E.	487.8	71.5	3.2	91.4	98.5	1.5	10.8	26.0	59.6	213.0	11.5
Developing M.E.	432.7	176.8	26.0	105.0	130.0	1.5	20.6	42.3	22.5	85.4	3.8
Central Planned	556.9	309.6	22.3	115.4	33.0	0.6	9.6	18.2	39.5	134.8	8.6

SOURCE: FAO 1977

Table 6. World cereal production (M.T. x 10^6)

Group of countries	Cereals Total	Wheat	Rice (paddy)	Maize	Millet and sorghum	Others ($)
World	1,459.0	386.6	366.6	349.7	98.3	257.9
Developed M.E.	502.3	140.2	23.4	205.6	22.1	111.0
Developing M.E.	426.9	84.8	191.6	77.4	53.4	19.7
Central planned	529.8	161.6	151.5	66.7	22.8	127.2

($) Others: Barley, Rye, Oats.
SOURCE: FAO, 1978

Table 7. Mean yield of cereals (Kg/Ha)

Group of Countries	Cereals Total	Wheat	Rice (paddy)	Maize	Sorghum	Millet
World	1,957	1,664	2,566	2,952	1,269	655
Developed M.E.	3,127	2,145	5,729	5,015	3,294	985
Developing M.E.	1,390	1,312	2,052	1,375	900	561
Central Planned	1,906	1,578	3,339	3,154	1,360	773

SOURCE: FAO, 1978

Table 8. World roots and tubers and sugar cane production (M.T. x 10^6)

Group of Countries	Roots and Tubers Total	Potatoes	Sweet Potatoes	Cassava	Other Roots and tubers (*)	Sugar Cane (as cane)
World	570.2	292.9	138.1	110.2	29.0	737.5
Developed M.E.	80.6	78.0	2.0	--	0.6	70.5
Developing M.E.	181.6	27.2	17.2	108.3	28.4	619.3
Central Planned	307.9	187.2	118.9	1.8	–	47.7

(*) Other roots and tubers: Cocoyam and Taro
SOURCE: FAO, 1978

Table 9. Mean yield of root and tuber crops and sugar cane (kg/ha)

Group of countries	Total Root and Tuber Crops	Potatoes	Sweet Potatoes	Cassava	Sugar Cane (as cane)
World	10,987	13,986	9,638	8,761	55,845
Developed M.E.	22,204	22,614	14,754	–	79,184
Developing M.E.	8,480	9,998	7,576	8,755	53,464
Central Planned	11,470	12,716	9,972	9,102	65,124

SOURCE: FAO, 1978

Table 10. World production of meat, eggs and milk for group of countries (M.T. x 10^6)

Group of countries	Total Meat	Beef Meat	Pig Meat	Poultry Meat	Other Meats	Eggs	Cow Milk
World	126.1	46.2	43.3	24.4	16.1	24.7	409.1
Developed M.E.	61.0	24.2	19.3	13.9	3.6	11.6	212.7
Developing M.E.	23.8	11.6	3.6	3.8	4.8	4.0	57.5
Central Planned	41.3	10.4	20.9	6.7	3.3	9.1	138.8

SOURCE: FAO, 1978
Own Calculations

Table 11. Yields easy to obtain in the tropics with appropriate ecological conditions and good agronomic methods. M.T./ha and M. cal/ha (1).

CEREALS:	M.T./ha	M. cal/ha.
Rice	3.0	7,980
Maize	2.5	8,575
Sorghum	2.0	6,500
ROOTS AND TUBERS:		
Cassava, dry meal	10.0	34,300
Cassava, dry foliage	25.0	34,000
Sweet potato, dry meal	6.0	15,000
LEGUME:		
Cannavalia ensiformis (Jack Bean)	2.0	?
SUGAR CANE:		
As Cane	75.0	31,700 (2)

(1) SOURCES: Estimated by the Authors, based in FAO Statistical information and experimental results, reported in the literature.

(2) This yield represents 31.7 millions k/cal of M.E., assuming 9.0% of sugar and 4.5% molasses, and is equivalent to approximately 17.0 M.T. of first sugar cane molasses.

Table 12. Feed requirement for the proposed poultry and swine production in the developing countries (1985)* (M.T.)

Human population (inhabitants)	2,477,796,000
Poultry Meat required (M.T.)	14,718,108
Swine Meat required (M.T.)	26,140,748
Eggs required (M.T.)	14,916,332
Poultry Feed required (as classical ration, M.T.)	85,174,337
Poultry Feed required (alternative ration, M.T.)	100,717,450
Swine Feed required (classical ration, M.T.)	130,703,740
Swine Feed required (alternative ration, M.T.)	156,844,482

(*) Feed efficiencies of 3.0 – 5.0 are utilized for the production of 1 kg of poultry meat, swine meat and eggs respectively with classical rations (prepared with cereals and oil meals); in the same order feed efficiencies of 3.6 – 6.0 and 3.2 are utilized with the alternative rations proposed.

SOURCE: FAO, 1978
Own Calculations

Table 13. Global composition of alternative poultry and swine rations for the tropics

Source	M.T. x 10^6 needed	Percentage of the ration	Area to be harvested (ha x 10^3)
First sugar cane molasses	77.2	30	4,451
Cassava root meal	64.4	25	6,440
Cassava foliage meal	25.7	10	1,028
Cannavalia meal	20.6	8	10,300
Sub-Total	187.9	73	22,309
Other components	69.7	27	?

SOURCE: Author's estimations based on experimental results reported, and own considerations.