CASSAVA AS ANIMAL FEED

Proceedings of a workshop held at the University of Guelph, 18-20 April 1977

Sponsored by the International Development Research Centre and the University of Guelph

El and Michael Graham
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Editors: Barry Nestel and Michael Graham

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/cassava/-based /feed/s — discusses methionine /amino acid/ supple-
mentation of cassava diets; metabolic pathways and their significance in
/animal nutrition/; single-cell /protein/ production (use of /bacteria/
to convert cassava into microbial protein); /animal feeding/ systems
for /swine/, /poultry/ and /cattle/; /feed production/ techniques such
as pelleting. /List of participants/, /statistical data/.

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Cassava in the Nutrition of Broilers

J. J. Montilla

One of the main obstacles to efficient animal production in the tropics is the lack of excess agricultural products that can be used as raw materials for animal rations. Cassava products (roots and foliage) appear to be one of the best possibilities for overcoming the chronic deficit in tropical agricultural production. The majority of the research carried out during the last 10 years shows that cassava root flour can be substituted for cereals in broiler rations at levels of up to 30%. When the diets are prepared in the form of pellets it appears possible to use cassava root meal and cassava foliage meal at levels up to 50 and 20%, respectively. The author strongly believes that even if a deterioration of 10% occurs in body weight increase and feed efficiency, cassava-based diets can be an economically feasible proposition within the framework of the developing countries. It is proposed that broiler feeding experiments utilizing cassava products not only evaluate body weight increase and feed efficiency, but also state the product yield in terms of production per hectare as this is a more logical approach to an agricultural activity. In addition, several areas of research requiring emphasis are suggested.

Although man’s interest in birds dates from the beginning of the first civilizations, their utilization as domestic animals destined for massive production of high value food for human consumption has been more recent. For example, the 9.3 million metric tonnes of eggs and 4.0 million tonnes of poultry meat produced in the world annually between 1948–52, rose to 22.3 million tonnes and 19.0 million tonnes, respectively, in 1972; an increase of 240 and 465% in only two decades (FAO 1973). This impressive increase permitted consumption of eggs and poultry meat to rise from 3.72 and 1.6 kg to 5.9 and 5.1 kg annually per capita, but it has not taken place evenly in all countries.

About 1663.5 million fowl in the developed countries of the western world produce 11.5 million tonnes of meat and 11.5 million tonnes of eggs. The less-developed countries, situated mainly in the tropical areas, produce only 2.3 and 3.3 million tonnes of meat and eggs respectively, in spite of their having 1780 million fowl; in the socialist countries 2340 million fowl produce 5.2 and 7.5 million tonnes of meat and eggs. The above data show the enormous difference in the human consumption of avian products (meat and eggs) that reaches, in terms of kilograms per person per year, 31.2 kg in the developed countries of the western world, only 3.1 kg in the tropical less-developed countries, and 7.3 kg in the socialist countries (FAO 1973).

The exceptional increase in poultry production achieved in the last few decades has been possible because of improvements in genetics, sanitation and hygiene, management, and nutrition. The goals achieved in these fields have been possible because of extensive investments of material and time. We can now say which countries can rely on good poultry genetic material, good sanitation and hygiene methods to control diseases and plagues, and good management systems, which give the birds adequate comfort for optimal production, without causing too great an investment on the part of the country concerned. Unfortunately the same is not true with animal nutrition. The development of avian production is one of the ways by which the western developed countries and the major part of the socialist bloc transform their agricultural excess into products more appetizing and of exceptional nutritional value. These excesses simply do not exist in a tropical area; on the contrary, there exists a deficiency with regard to direct human nutrition. For this reason, only countries like Venezuela (with an enormous income due to revenues from oil exportation, which allows exceptionally high importation of raw material for animal feeding) have developed avian production to provide an important contribution to human nutrition.

The principal plant harvests on a world basis are cereals (1275 million tonnes), of which the developed countries of the western world and the socialist bloc countries produce 452 and 457 million tonnes respectively, i.e. 35.5 and 35.8% of the total; the developing countries, with 47% of the human population, only produce 367.3 million tonnes (28.7%). The situation is graver still when one considers that in

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the developing countries 289.6 million ha are cultivated, which represents 41.5% of the world area utilized for this type of cultivation. The situation is very similar for roots and tubers, which occupy second place in relation to the volume of world production; the developing countries only produce 29.5% of the world total (166.2 million tonnes, of a total of 563.4 million tonnes).

The tropical developing countries only lead in the production of crops of lesser importance in relation to the total volume produced, such as grains, fruits, vegetable oils, sugar, coffee and cocoa, vegetable fibres, tobacco, and rubber. It must be considered that a significant part of the production is not devoted to internal consumption but is exported.

A much more serious problem is detected when the world production of animal food is analyzed. The developed countries of the western world, with 20% of the total human population, produce 48.8% of the meat, 49.4% of the milk, and 51.3% of the eggs. The socialist bloc countries, inhabited by 33% of the human population, produce 33%, 29.9%, and 33.5% respectively. The developing countries, with 47% of the population, produce only 18.3% of the meat, 19.9% of the milk, and 14.7% of the eggs.

In summary, of the 2751 million tonnes of plant products produced in the world, 827 million tonnes (30%) come from the developed countries, 840 million tonnes (30.5%) from the developing countries, and 1087 million tonnes (39.5%) from the socialist countries; of the 546.4 million tonnes of animal products for human consumption, 269.6 million tonnes (49.3%) are produced in the developed countries of the western world, 109.4 million tonnes (18.1%) in the developing countries, and 167.4 million tonnes (32.6%) in the socialist countries.

Cassava, until recently relegated to the area of scientific research, is without doubt one of the best possibilities for overcoming the chronic deficit in tropical agricultural production. This type of cultivation, without the technological expertise that is applied to the production of cereals, and with a minimal input, gives an average production of 10000 kg/ha in the tropics, equivalent in energy value to 3500 kg of cereal. In countries such as Brazil, average production is already higher than 15000 kg/ha. Harvests of more than 30 tonnes of roots per hectare are commonly obtained in Venezuela, and it is considered that this volume of production is a feasible goal when the cultivation of high-yielding varieties becomes more generalized, and when suitable methods of cultivation are applied (Montaldo 1973).

Without question, green plants represent the most abundant and economical source of protein because they synthesize amino acids through photosynthesis, which is based on primary products available in unlimited amounts: solar energy, carbon dioxide, water, and inorganic nitrogen (atmospheric in the case of legumes). The amino acids synthesized in this way are polymerized into a more stable form as proteins, and stored in the leaves. As the process takes place, principally during the early leaf stage, the tender green leaf material possesses the greatest protein value (Oke 1973).

In this respect, cassava foliage cut at intervals of between 60 and 90 days constitutes an excellent possibility (Montilla 1976).

There exists sufficient evidence to demonstrate the feasibility of utilizing cassava root flour as an energy source, and cassava leaf flour as a supply of certain of the protein requirements in broiler feeds.

**Cassava Root Flour**

Cassava is one of the oldest crops in tropical America. The Indians learned how to process the root by drying it and converting it into a product which, in addition to increasing its useful life span, became harmless due to the elimination of hydrocyanic acid (HCN), which is especially abundant in the so-called "sour" varieties. Following the discovery of America, cassava was passed to the tropical areas of Africa and Asia where it soon became a basic food. However, it is only during the last few decades that interest has been shown in utilizing it in balanced feeds for animals.

In 1935, Tabayoyon in the Philippines, studied a product derived from the extraction of cassava starch, the chemical composition of which was: moisture 10.56%; protein 1.03%; fat 0.62%; crude fibre 4.76%; ash 1.22%; and carbohydrate 81.91%. This material was incorporated at 30 and 60% levels into mixes for chicken production, together with other ingredients such as rice bran, corn meal, and shrimp meal. Body weights at 12 weeks were 517.7, 463.4, and 388.0 g for birds that ate feeds containing 0, 30, and 60% of the cassava
by-product. The amount of feed consumed was 2.55, 2.28, and 2.24 kg. The results of this work are of great importance when one starts to think of cassava not only with regards to its direct use as food for man and domestic animals, but also its increased use for industrial processing.

Olson et al. (1969) determined the metabolizable energy (M.E.) of cassava root flour, prepared by peeling and grinding the root, compressing it to remove water, and drying in an oven at approximately 100 °C. These workers reported caloric values of 3.44 and 3.09 kcal/g of M.E. for the dry and the 10% moisture flour, respectively. In 1972 Maust et al. determined the M.E. of cassava root flour from Thailand classified as "suitable for human consumption." The flour contained 1.1% neutral detergent fibre, 0.0% acid detergent fibre, 0.1% crude protein, and 4306 kcal/kg of total energy. The M.E. value (dry base) was 4.31 kcal/g. Muller et al. (1974) reported M.E. values in Singapore of 3650 kcal/kg for cassava root flour and 3660 kcal/kg for yellow corn grain. Hutagalung et al. (1974) report an M.E. level of 3230 kcal/kg for cassava root flour. Such diverse energetic values are due to the use of different products. They may also reflect differences in chemical composition caused by age, time of harvest, and methods of processing (Barrios and Bressani 1967).

With respect to the digestibility of the cassava root flour fractions by poultry, Vogt (1966) reports crude protein 75%, crude fat 70%, crude fibre 55%, and nitrogen-free extract 99%.

McMillan and Dudley (1941) fed chickens diets containing 20 and 40% cassava root flour and did not notice deleterious effects on health; however, the higher level of substitution produced a reduction in weight gain.

Klein and Barlowen (1954) recommended using cassava root flour at levels of up to 10%, because higher levels were reported to decrease weight gain and feed efficiency. They affirmed that cassava flour contained a factor that diminished feed consumption. Wegner (1961) obtained satisfactory results by feeding broilers rations containing 8% cassava root flour.

Vogt and Penner (1963) incorporated up to 30% cassava root flour into broiler rations. Productivity was normal with 10%, but with 20 and 30%, weight gain and feed efficiency deteriorated. According to these workers the adverse effect occurs mainly in the first few weeks of life. Vogt (1966) affirmed that only after the fourth week can broilers consume cassava root flour at levels higher than 10%.

Yoshida et al. (1966) found that young birds grew well when fed with 10% cassava root, but that higher levels resulted in delayed growth. Moistening the cassava overnight or autoclaving it at 120 °C for 1 h significantly increased the rate of growth of the birds. The authors suggested that HCN, present in the flour (36 ppm), was responsible for the low level of growth.

Enriquez and Ross (1967) studied in 1-day-old Leghorn chicks the effect of incorporating up to 50% cassava root flour into a diet whose principal protein source was formed by fish meal, meat and bone meal, and soybean flour. The composition of the cassava flour was: moisture 11.78%; crude protein 1.73%; crude fat 0.50%; crude fibre 2.2%; ash 3.79%; and nitrogen-free extract 80.09%. The fresh material came from a sweet clone, and was obtained from plants 11-16 months old. The cassava was harvested, washed, cut, and dried for 24-48 h in a grain drier at 50 °C. The flour prepared in this way showed very low levels of HCN. At 3 weeks of age, deterioration in weight gain and feed efficiency was statistically significant when cassava flour levels in excess of 20% were used. The addition of molasses and soybean oil had no beneficial effect, which demonstrated, according to the authors, that the problem was not one of palatability or essential fatty acid deficiency. On the other hand, supplementation with 0.15% methionine corrected the adverse effects. The authors concluded that if the ration was balanced with respect to protein and methionine, cassava flour could satisfactorily replace all the corn in the diet. The response to methionine was probably due to the fact that by increasing the levels of cassava in the rations it was also necessary to increase the levels of soybean flour (in the protein of which methionine is the most limiting amino acid). Olson et al. (1968) affirmed that although cassava root flour contains 92% of the M.E. of corn, they only obtained a 72% weight increase and a deterioration of feed efficiency when compared with the cereal.

Soares et al. (1968) studied levels of partial and total substitution of corn with cassava root flour in 1-day-old New Hampshire chicks, and also substitution of the corn with approximately equal amounts of cassava root flour and
wheat flour. In the first instance the cassava flour reached a maximum incorporation of 34.30% in the ration, and in the second case the cassava plus wheat reached 20.16%. The best weight increases and feed efficiencies were obtained with 12 and 18% cassava flour, and with 6 and 12% of the mixture. Majarrez et al. (1973) combined cassava flour and rice polishings in the proportion 40:60, and called the mixture “cassavarice.” These workers considered that the mixture could partially substitute grain in balanced diets. In 1-week-old broilers, they studied levels of 0, 50, and 100% “cassavarice” as a corn substitute, using exclusively isoprotein rations. No significant differences were encountered with reference to weight increase, but differences were detected in relation to feed efficiency (p < 0.01). The mean values were 2.41, 2.37, and 2.93, respectively, for the different levels used. They concluded that the use of “cassavarice” was possible, its use being dependent on the price of the raw materials.

Rendon et al. (1969) studied the incorporation of 0, 15, 30, and 45% cassava root flour in diets for broilers, and reported a decrease in weight gain and feed efficiency for all levels studied; however, with the 15% level the differences were lower. The authors confirmed the existence in cassava flour of a factor that reduced feed intake in birds receiving the highest levels. Gadelha et al. (1969), using 1-day-old broiler chicks, studied the effects of substituting cassava root flour for corn at levels of up to 45% in diets supplemented with 0.20% methionine. They observed a decrease in weight gain and feed efficiency at all levels studied; however, the lower cost of the cassava flour made the 15% diet more economical. The consumption of the food was not affected in these diets.

Olson et al. (1969) tested peeled cassava root flour in broiler rations, incorporating it in amounts from 7.5 to 45.0%, and making the rations isocaloric and isoproteinaceous by means of the addition of animal fat and soybean flour. They found that although the gain in weight was slightly reduced by increasing the incorporation of cassava flour, significant differences only appeared at the higher levels (37.5 and 45.0%); the feed efficiency response was similar. They concluded that peeled cassava root flour could be incorporated into diets for chicks at levels of up to 30% without affecting weight increase if the feed was balanced for energy and protein. Tejada and Brambila (1969) studied the incorporation of up to 50% (0, 12.5, 25, 37.5, and 50%) washed cassava root flour in diets for Leghorn chicks, in substitution of corn, and found no significant differences in relation to weight increase or feed efficiency.

Montilla et al. (1969) studied in 1-day-old Vantress × White Rock chicks the effect of incorporating 0, 15, and 30% sweet cassava root flour in rations whose principal protein sources were the following flours: sesame, cotton seed, meat and bone meal, and fish meal. The cassava root flour was obtained from unwashed sun-dried roots (approximately 36 h). The weight increases by the 6th week were very similar: 995 g, 995 g, and 981 g for diets with 0, 15, and 30% cassava root flour, respectively. Feed efficiency decreased in a linear fashion, with values in the same order of 2.03, 2.09, and 2.19; feed consumption increased from 2.020 kg in the basal ration to 2.151 kg at the 30% cassava flour level. The authors suggested that the deterioration in the feed efficiency could be a result of the powdery characteristic that the cassava root flour gave to the rations. Montilla et al. (1970), using the same levels of substitution, added to all the diets 5% animal fat and 5% sugar cane molasses with the object of eliminating the powdery characteristic given by the cassava root flour. At the 8th week, no significant differences in feed consumption, weight increase, or feed efficiency were detected between the treatments. Feeding costs were reduced by 7.4 and 9.8% for the chicks that received rations containing 15 and 30% cassava.

Vogt and Stute (1964) had already observed that better results were obtained when dehydrated cassava root flour was pelleted, and they suggested that the feed intake could be negatively influenced by the excessively fine nature of the flour. Müller et al. (1974), considering the specific weight of a corn-based diet to be 100, found that this value decreased to 81 when 40% cassava root flour was used as a corn substitute, but that it increased to 109 when the feed was pelleted. Chou and Müller (1972) substituted pelleted cassava root flour for corn flour at levels of up to 58%, and found that this substitution was possible provided that the diets were duly balanced with regard to other nutrients. They emphasized that toxic or growth-retarding factors were not observed. Palisse and Barratou (1974) re-
placed 23% of the corn or wheat with 20% cassava root flour, 2% animal fat, 1% soybean flour, and 60 g methionine, without encountering significant differences with respect to feed consumption, weight gain, and feed efficiency, provided that the rations were prepared in the form of pellets.

Armas and Chicco (1973) replaced corn with cassava flour in broiler diets containing corn flour, soybean flour, sesame flour, meat meal, and fish meal. The cassava flour was incorporated at levels of 18, 36, and 54% in the diets (which were isocaloric and isoproteinous), and they found no significant differences with respect to weight increase and feed efficiency, although with the diet containing 54% cassava flour the weight increase was reduced by 8.1%. The fact that the diets contained 8 or 16% animal protein, or were supplemented with 0.3% methionine and 0.3% lysine, did not affect the results. According to Sebastia et al. (1973), feed consumption was not affected in broilers by the substitution of up to 50% of the sorghum by cassava root flour. They found a significant weight gain difference, the best diet being that in which 30% of the sorghum was substituted by cassava root flour; higher levels of substitution gave rise to a marked deterioration in weight increase and feed efficiency.

Montilla et al. (1975) partially (30% of the diet) and totally (37% of the ration) replaced corn flour with "sour" cassava root flour (785 ppm HCN in fresh cassava, and 50 ppm in the flour). In both cases 11% of the corn had been replaced by 9% sugar cane molasses and 2% animal fat to eliminate the powdery characteristic of the rations. These rations, given to 1-day-old Vantress × White Rock chicks, resulted in very similar weight gains at the 4th week in the case of diets containing 0 and 30% "sour" cassava flour; at the 37% level the weight gain dropped by 9.0% (highly significant). The same authors compared base rations (starters and finishers) with rations containing 30% "sweet" cassava root flour (0 ppm HCN) or 30% "sour" cassava root flour (50 ppm HCN) (Table 1).

The "sour" cassava behaved in a slightly inferior manner with regard to weight increase and feed efficiency, probably because of its HCN content (50 ppm). It would appear that, even accepting the affirmations by Tejada and Brambila (1969) and Jalaludin and Yin (1972) that birds (Gallus) are exceptionally resistant to HCN intoxication, it is necessary to obtain (by adequate processing) a product that does not contain HCN, or which contains it in a very low proportion. It is worth noting that the cassava flour used in all the experiments carried out by Montilla was sun dried.

Phuah and Hutagalung (1974) provided meat-type chicks with rations having three protein levels (19, 22, and 25%) and three cassava flour levels (0, 20, and 40%) over the period of 3–6 weeks of age. After 3–6 weeks of age they gave the same levels of cassava but reduced the protein levels to 17, 20, and 23%. They found that the percentage carcass yield (dry basis) and carcass yield protein were significantly higher, and that the production of fat was lower with 20% cassava root flour. The digestibility of the protein was reduced, and that of the fat was increased, when the percentage of cassava was increased in the diet. They concluded that cassava flour had no adverse effects when the diet was supplemented with methionine, lysine, and palm oil.

Cassava Leaf and Foliage

Miranda et al. (1957) conducted two experiments comparing chick rations containing 5% of either alfalfa (Medicago sativa) hay, tropical kudzu (Pueraria javanica) hay, cassava (Manihot esculenta) hay, or Desmodium discolor hay. The body weights obtained with all the rations at 8 and 12 weeks did not differ significantly. They concluded that any of the four hays produced satisfactory results under the conditions of the experiments.

Ross and Enriquez (1969) studied the effects of incorporating cassava leaf meal at levels of up to 20% in rations for 1-day-old male Leghorn chicks. The fresh material utilized in the first two experiments was from plants 11–15 months old, and from younger plants for subsequent experiments. The flour prepared with these materials had a protein content of 14.8% in the first case, and approximately 18.0% in the others. The flour was prepared by drying the leaves overnight in a drying chamber at 50 °C. The HCN content of one of the flours utilized was 554 ppm. From the first experiments it was concluded that cassava leaf flour depressed body weight increase and feed efficiency when it was incorporated at levels higher than 3%. Supplementation with 0.15% methionine and 3% maize oil overcame the adverse effects at all levels. According to
these authors, methionine appears to be the first limiting factor and energy the second one in chick diets containing cassava leaf flour. A marginal methionine deficiency may have been responsible for some of the growth depression, although the presence of appreciable quantities of cyanogenetic glucoside in cassava leaves suggests that cyanide toxicity may have been responsible for a relative methionine deficiency. Because the growth effect from supplemental methionine was greater than could be explained from the methionine content of the rations, the hypothesis was advanced that cassava leaf rations required methionine to provide additional sulfur for cyanide detoxification. The addition of 0.15% sodium thiosulfate to the 20% cassava leaf ration significantly improved growth, supporting this hypothesis.

Agudu (1972) compared cassava (Manihot utilissima) and Madras thorn (Pithecellobium dulce) leaf flours, a synthetic xanthophyll material, and two sources of yellow corn as sources of yolk pigments in White Leghorn pullets. Cassava leaf flour appears to be a good source of pigments.

Montilla et al. (1973) found no significant differences in body weight gain, feed efficiency, or pigmentation effect when they compared 2.5% cassava foliage flour (from 3-month-old plants) with the same level of alfalfa flour in broiler rations. Cassava foliage flour can be incorporated at relatively high levels in pelleted broiler rations. These results, and research in progress, suggest that oil-seed meals can be reduced by up to 30% by using cassava foliage flour at levels between 16 and 20%. In the cassava foliage flour used by the author HCN was not detected, although the fresh material had about 500 ppm; whereas, the flour used by Enriquez and Ross (1969) had 554 ppm. The difference may be in the processing: sun-drying versus drying chamber at 50 °C.

Table I. Results after 6 and 8 weeks of the substitution of 30% "sweet" or 30% "sour" cassava root meal in chick diets.

<table>
<thead>
<tr>
<th>Weight increment (kg)</th>
<th>Feed efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% cassava</td>
<td>1.056</td>
</tr>
<tr>
<td>30% &quot;sweet&quot;</td>
<td>1.034</td>
</tr>
<tr>
<td>30% &quot;sour&quot;</td>
<td>1.014</td>
</tr>
</tbody>
</table>

10% of cassava foliage replaced 7.5% of a sesame-cotton seed flour mix (3:1) and 2.5% maize. Diets were fed as either mash or pelleted. When mash diets were used, body weight increment and feed efficiency were adversely affected at each level of cassava foliage substitution from 0 to 6 weeks of age. Body weight gains were similar for all treatments for the 6-10-week-old birds. Feed efficiency in the 6-10-week-old groups gave similar results except at the 30% level, in which the response was poor. Pelleted diets up to 20% showed good improvement in body weight increments; birds reaching market weights at 8 weeks of age. Feed efficiency was poor in the pelleted diets, probably because a high capacity pelleting machine was used to process small quantities of feed. Steam injection could not be controlled and the pelletization occurred mostly dry, probably destroying and/or impairing some nutrients. The results suggest that cassava foliage flour can be incorporated at relatively high levels in pelleted broiler rations. These results, and research in progress, suggest that oil-seed meals can be reduced by up to 30% by using cassava foliage flour at levels between 16 and 20%. In the cassava foliage flour used by the author HCN was not detected, although the fresh material had about 500 ppm; whereas, the flour used by Enriquez and Ross (1969) had 554 ppm. The difference may be in the processing: sun-drying versus drying chamber at 50 °C.

Hutagalung et al. (1974) using 2-week-old meat-type chicks studied the effects of incorporating in a basal diet (a) (principal ingredients were soybean flour and corn flour) the following: 10% (b) and 20% (c) cassava leaf flour; 20% (d) and 40% (e) cassava root flour; 10% cassava leaf flour and 30% of cassava root flour (f); and 15% cassava leaf flour and 30% cassava root flour (g). The body weight increments were: 18.2; 15.7; 15.2; 18.4; 16.0; 15.8; and 15.7 g/day for diets a, b, c, d,
e, f, and g, respectively. In the same order, the feed efficiency was: 3.12; 3.36; 3.81; 3.14; 3.24; 3.64; and 3.81. The chicks receiving the cassava leaf flour did not consume enough feed to meet their nutrient requirements, particularly energy and protein, probably because of a reduction in nutrient density. As well, they referred to the incomplete elimination of the growth depressing factor in the cassava leaf flour.

The estimated cereal requirements for Venezuela are about 6.2 million tonnes (about 2.2 million tonnes for poultry and swine feeding). With actual cereal crop yields of about 1.3 tonnes/ha (which is similar to that obtained in most tropical countries), this would require the planting of about 4.6 million ha. If cassava and sugar cane (with rice as the main cereal crop) were used on a large scale the required area for planting would be reduced to less than 1 million ha. Good cassava varieties, with proper planting techniques, yield 10 tonnes/ha/year of dry roots and 30 tonnes/ha/year of cassava foliage flour, which would produce (at 20% protein) 6 tonnes of protein/ha/year. At the present time sugar cane is yielding 7 tonnes of sugar and about 3.5 tonnes of molasses/ha/year, and rice yields approximately 3.0 tonnes/ha/year.

The following points are emphasized:

1) Cassava root flour with which research on broiler nutrition has been carried out has not been uniform either in composition or in method of processing. Whole cassava root flour, from roots washed or unwashed, peeled or unpeeled, oven-dried following crushing to remove water, dried in driers and sun-dried respectively have been used. If to this are added the variations among varieties with respect to chemical composition, it is difficult to expect that the results would be homogenic. It is suggested that attempts be made to experiment with, and define the composition of, whole washed sun dried cassava root flour and with whole flour dehydrated by the D’Andrea process which seems to be the most appropriate, at least for the developing countries.

2) Most of the research carried out during the last 10 years shows that cassava flour can be incorporated into broiler rations at levels of up to 30%, in substitution of cereals. As is the case with any energy source, it is necessary that the diet be balanced.

3) Supplementation with methionine seems necessary only when the basic protein source is soybean flour and/or appreciable amounts of HCN are found in the flour.

4) When the diets are prepared in the form of pellets cassava root flour can be incorporated into broiler diets at levels of 50% or more. The beneficial effect of pelleting is explained by the consideration that the digestive tract of birds is short and of little physical capacity; for these reasons, in their feeds, one not only has to consider the concentration of nutrients per unit of weight, but also per unit of volume. Cassava flour is a material of relatively low density, a limitation which is overcome by pelletization.

5) When pelletization is not possible, molasses and/or animal or vegetable fats must be incorporated into the diet to eliminate the powdery characteristic that cassava flour confers upon the rations, which can adversely affect feed consumption.

6) It appears impractical to think of collecting and processing the leaves of the cassava plant alone. However, it seems more logical to consider cassava foliage as distinct from cassava roots and harvesting it at time intervals of between 60 and 75 days.

7) It appears possible to utilize up to 50% cassava root flour and 20% cassava foliage flour in pelleted broiler diets, these amounts replacing almost all the cereals and up to as much as one third of the oil-seed meals.

8) It is important that broiler feeding experiments utilizing cassava products should not only evaluate body weight increase and feed efficiency, but also state the product yield in terms of production per hectare (tonnes/ha) as this is a more logical approach to an agricultural activity. Countries in temperate areas are obtaining between 1.5 and 2.0 tonnes of broilers (live weight) per hectare using cereals and soybean flour as the chief ingredients of the diets. These levels of production could be achieved, and even surpassed, in tropical areas if products from cassava and other high yielding tropical crops were to be used. Currently, in the tropical areas of the world, classical broiler diets produce slightly over 0.4 tonnes of broilers per hectare.

Some areas of research which should be emphasized are:

1) Drying methods for roots from “sour” cassava varieties and for foliage of all varieties, to render the feedstuffs innocuous.

2) Processing and utilization of mixed cassava root and foliage to take advantage of the high enzyme concentration (for HCN liber-
ation) in the foliage. This would provide a product relatively high in energy and with approximately 9% protein, when combined in the proportion of 1:1 on a fresh basis.

(3) Levels and combinations of cassava root flour and cassava leaf flour, and of both with other ingredients including amino acids, vitamins, and minerals, for the periods of the broiler production cycle (growing and finishing).

(4) HCN removal from cassava foliage is total when it is sun dried, but not when a drying chamber (50 °C) is used. Studies should be carried out on leaving the fresh previously cut material overnight, as this would help in obtaining innocuous products when fast drying is used.

(5) The economics of the whole production process comparing classical cereals-soybean flour diets with diets based on cassava products should be reviewed. The author strongly believes that even when a deterioration of 10% occurs in body weight increase and feed efficiency, diets based on cassava products are an economically feasible proposition in developing countries.