THE GLOBAL CASSAVA DEVELOPMENT STRATEGY

Cassava for livestock feed in sub-Saharan Africa

IFAD
INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT

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Cassava for livestock feed in sub-Saharan Africa

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F O R E W O R D

Historically, cassava has played a minor role as an ingredient in livestock feed in sub-Saharan Africa as cassava was often more expensive than imported maize for this purpose. However, the recent rising cost of maize on the continent due to weather induced fluctuations, huge foreign debts and currency devaluation has forced a number of countries in Africa to look inwards for alternatives to maize particularly for its livestock sub sector. With restricted fertilizer availability and frequent drought in many regions of Africa, local production of this commodity has dwindled and yield is becoming increasingly unpredictable.

Livestock production systems in Africa remain largely traditional with over 90 percent reared on the extensive system of management depending largely on poor quality forage and occasional supplement from food wastes. The share of African cassava production used as livestock feed is estimated at 6 percent of the total production. It is probably underestimated because cassava roots and leaves are fed to sheep, goat and pigs on small-scale farms in the cassava producing areas, either in fresh or cut-and-dried form or as by-products of cassava processing.

With higher productivity expected from new improved varieties and cost saving production and processing technologies, a surplus in cassava production is anticipated that could lower the farm price of cassava. This scenario has led to growing interest among government authorities, the private sector and researchers in Africa on the improvement of processing and utilization of cassava for its livestock industry, which is currently faced with a limited supply of raw materials.

The need to diversify and expand cassava usage into new growth markets had prompted the development of the Global Cassava Development Strategy that was formulated by the International Fund for Agriculture Development (IFAD) and the Food and Agriculture Organization of the United Nations (FAO) in collaboration with selected national institutions, the International Center for Tropical Agriculture (CIAT), the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), the International Institute of Tropical Agriculture (IITA) and the Natural Resources Institute (NRI). The strategy was endorsed at the International Validation Forum jointly organized by FAO and IFAD in Rome, Italy in April 2000. It suggests that cassava development should be demand-driven, and take advantage of market opportunities for traditional and new products.

In line with the strategy, presidential initiatives on cassava have been recently developed in West African countries of Nigeria, Ghana and Benin to tap on the huge domestic market for cassava as raw material for industry and create opportunities for income generation of the rural population. The use of cassava in the animal feeds industry may be one of the important starting points of introducing cassava in the main stream industrial processing as the quality of the required cassava material may not be as stringent as in other industrial uses.

However, important questions need to be answered such as what can be done to increase the use of cassava in livestock feed in Africa. And, to what extent does cassava provide a balanced and/or an important cost-effective input into the feed mix and how will it compare with other feed ingredients.

This case study documents research findings and existing data from micro-sample surveys on cassava usage in livestock feed in selected African countries. It summarizes the livestock production and feeding patterns on the continent and contributes to the better understanding of the competitiveness of cassava as compared with cereals. Strategies for expanding cassava beyond its traditional use as food and its transformation to livestock feed component in sub-Saharan Africa are recommended.

We trust that the information available will not only increase awareness on the new uses and opportunities in livestock feed and the need for favourable policies to enhance cassava competitiveness and marketing but will also effectively contribute to the adoption by farmers and livestock feed producers of cassava root and leaf meal-based formulations with partial or complete replacement of maize for livestock species in Africa.

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ACRONYMS AND ABBREVIATIONS

CIAT	International Center for Tropical Agriculture
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
COSCA	Collaborative Study on cassava in Africa
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO Statistical Data
HCN	Hydrocyanic acid
IFAD	International Fund for Agriculture Development
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
ISTRC-AB	International Society for Tropical Root Crops – Africa Branch
NRI	Natural Resources Institute
TMS	Tropical Manioc Selection
WHO	World Health Organization

CASSAVA FOR LIVESTOCK FEED IN SUB-SAHARAN AFRICA

1. INTRODUCTION

Sub-Saharan Africa is bordered to the north by Mauritania, Mali, the Niger, Chad and the Sudan and extends to the southern tip of the continent. Its livestock production systems remain largely traditional with over 90 percent reared on the extensive system of management depending largely on poor quality forage and occasional supplement from food wastes. Shortage of quality feed constitutes the major input limiting livestock productivity. The energy component of livestock feeds constitutes the largest proportion of compound rations for efficient productivity. Maize presently dominates the energy supply in such rations. With restricted importation due to huge foreign debts and currency devaluation in most African countries, its price has risen astronomically. With restricted fertilizer availability and increasing drought in many regions of Africa, local production of this commodity has dwindled and yield is becoming increasingly unpredictable. Many national cassava improvement programmes in Africa have released improved cassava varieties. Higher productivity is therefore expected from the improved varieties and production technologies. As a result, a surplus is anticipated that could lower the farm prices of cassava products.

The historical and current trend where cassava plays a minor role as an ingredient in livestock feed in Africa is therefore envisaged to change as it is a proven substitute for maize in livestock rations in the European Union and Latin America. The major future market for increased cassava production on the continent is as livestock feed as it offers tremendous potential as a cheap source of food energy for animals, provided it is well balanced with other nutrients. There is therefore a great deal of current interest in supplemental feeding of animals with cassava in Africa.

This monograph summarizes the nutritive value and toxicity of principal parts of the cassava plant. It also documents the livestock production and feeding patterns on the continent providing an analysis of existing data from micro sample surveys on cassava usage as livestock feed in selected African countries. The competitiveness of cassava as compared with cereals as well as linear programmed feed formulations of cassava plant-based rations is provided for different livestock and fish species. Strategies for expanding cassava beyond its traditional use as food and its transformation to an important livestock feed component in sub-Saharan Africa are recommended.

2. AN OVERVIEW OF CASSAVA IN SUB-SAHARAN AFRICA

2.1 Cassava properties

Cassava is one of the most drought tolerant crops and can be successfully grown on marginal soils, giving reasonable yields where many other crops do not grow well. Cassava is adapted to the zone within latitudes 30° north and south of the equator, at elevations of not more than two thousand meters above sea level, in temperatures ranging from 18-25°C to rainfall of fifty to five thousand millimetres annually and to poor soils with a pH from 4 to 9. It is a perennial plant growing to a height ranging from 1 to 5 m with three-core single or multitude branching stems. The leaves are deeply, palmately lobed and the roots are enlarged by deposition of starch cells which constitute the principal source of nutrients. Roots' bulking occurs usually between the 45th and 60th day after planting and storage roots building is a continuous process. An average storage root yield of 5-12 tonnes/ha has been reported by traditional methods of cultivation; but by cultivating high yielding varieties and following better production practices, yield can increase to 40-60 tonnes/ha. Cassava's productivity in terms of calories per unit land area per unit of time is significantly higher than other staple crops as cassava can produce 250 x 10^3 cal/ha/day compared with 176 x 10^3 for rice, 110 x 10^3 for wheat, 200 x 10^3 for maize and 114 x 10^3 for sorghum (Balagopalan *et al.*, 1988).

2.2 Nutritional profile

The principal parts of the mature cassava plant expressed as a percentage of the whole plant are leaves 6 percent; stem 44 percent and storage roots 50 percent. The roots and leaves of the cassava plant are the two nutritionally valuable parts, which offer potential as a feed source. The cassava storage root is essentially a carbohydrate source. Its composition shows 60-65 percent moisture, 20-31 percent carbohydrate, 0.2-0.6 percent ether extracts, 1-2 percent crude protein and a comparatively low content of vitamins and minerals. However, the roots are rich in calcium and vitamin C and contain a nutritionally significant quantity of thiamine, riboflavin and nicotinic acid. Of its carbohydrate, 64-72 percent is made up of starch. The starch content increases with the growth of the storage roots and reaches a maximum between the 8th and 12th month after planting. Thereafter, the starch decreases and the fibre content increases. Cassava starch contains 20 percent amylose and 70 percent amylopectin. Cassava roots also contain sucrose, maltose, glucose and fructose in limited levels. The raw starch of the cassava root has a digestibility of 48.3 percent while cooked starch has a digestibility of 77.9 percent.

Cassava root is a poor source of protein. The quality of cassava root protein is however, fairly good as far as the proportion of essential amino acid as a percentage of total nitrogen is concerned. Methionine, cysteine and cystine are however limiting amino acids in the root. Only about 60 percent of the total nitrogen is derived from amino acids and about one percent of it is in the form of nitrates, nitrites and hydrocyanic acid. The remaining 38-40 percent of the total nitrogen remains unidentified. Peeling results in the loss of part of the valuable protein content of the root because the peel contains more protein than is found in the root flesh. The amino acid level of cassava roots show higher levels of lysine and trypophan in its true protein fraction.

The lipid fraction of cassava flour is 2.5 percent and is 50 percent extractable with conventional solvents (Hudson and Ogunsua, 1974). The extractable lipids are mainly polar in nature, the principal group being galactosy/diglycerides. The cassava root is a relatively poor source of minerals and vitamins, however, there is a high content of calcium and phosphorus in the storage roots. The mineral content of the dry bark is higher than that of the cortex. Calcium values in the whole root range from 15-129 mg/100 g, while phosphorous values are approximately 100 mg/100 g. The content of iron in the central cylinder is 32 mg/100 g, while in the bark, it is 77 mg/100 g. Vitamin C content of raw roots range from 38.5-64.6 mg. Drying reduces the vitamin C content apparently, with values going down to 2-13 mg/100 g.

The annual yield of cassava foliage has been reported to be as high as 90 tonnes fresh leaves/ha/per annum if harvested three times a year (Sicco, 2002 personal communication). This however, has a depressing effect on storage root yield. Lower values up to 12 tonnes/ha/annum have been obtained without reduction in root yield. Cassava foliage is therefore a highly nutritive and economically feasible high protein ingredient of animal feed rations. Dried cassava leaves have vast scope as a protein ingredient in compound feeds for livestock and poultry. Cassava leaf blades are especially rich in protein (average 30.5 percent) and the protein content reduces to 13 percent for whole foliage (Gramacho, 1973). Essential and non-essential amino acids can be found in good levels in cassava leaves. Cassava leaves and roots are low in methionine with values of 1.7 and 1.2 g/100 g of crude protein compared with 2.2 g, for the FAO reference pattern. Lysine content is high in the leaves (7.2 g) and low in the roots (3.9 g) compared with the FAO pattern (4.2 g). The biological value of cassava is inferior to that of animal protein. A major proportion of the leaf carbohydrate is starch. The amylose content of the leaf starch has been reported to range from 19-24 percent.

The crude fibre content of cassava leaves is low which makes it palatable as poultry feed. However, when harvested with the tender stem the fibre becomes as high as 13.9-16.9 percent. The leaves are rich in calcium but low in phosphorus compared with maize and sorghum (Tewe *et al.*, 1976).

Cassava foliage meal contains as high as 56 000 IU of vitamin A as compared with 14 200 IU in alfalfa meal, 66 IU in ground yellow maize and 264 IU in wheat flour. This high content of vitamin A is significant in the pigmentation of egg yolk and skin of poultry.

2.3 Toxic factors in cassava

The cyanogenic glucosides of cassava (Linamarin and Lotaustralin) on hydrolysis releases hydrocyanic acid (HCN). The presence of cyanide in cassava has caused a global scare as to the safety of cassava and its products for human and animal consumption. The concentration of the glycosides varies considerably between varieties and also with climatic and cultural conditions. The normal range of cyanoglucosides content in fresh roots is from 15-400 ppm calculated as mg HCN/kg fresh weight but occasionally varieties with very low HCN content of 10 mg/kg or very high HCN content of 2 000 mg/kg have been reported. Cassava is often classified as "bitter or sweet" according to the amount of cyanide present. However, several studies have shown that bitterness or sweetness could not be exactly correlated with the level of cyanogenic glucosides. Earlier classifications of cassava safety limits provided by Bolhuis, 1954 indicate:

- innocuous: less than 50 mg HCN/kg/fresh peeled storage root;
- moderately poisonous: 50-100 mg HCN/kg fresh peeled storage root;
- dangerously poisonous: over 100 mg HCN/kg fresh peeled storage root.

A comprehensive study on the cyanogenic character of cassava and its implication in productivity of livestock has been reported (Tewe, 1997). Safe levels of cyanide in cassava-based rations have been deduced from various studies for different classes of livestock and poultry. At a level of 100 ppm (100 mg HCN/kg, dried chips) satisfactory growth can be obtained in livestock provided the feed is adequately supplemented with protein (or specifically methionine) and iodine.

In long-term trials, the carry over effect of cyanide, particularly for gestating animals, can be deleterious as placental thiocyanate transfer occurs in gestating pigs consuming cassava-based feeds with a HCN level of 500 ppm. Through proper processing however, cyanide levels of less than 50 ppm can be obtained particularly in sundries samples.

Presently, safety limits for cyanide in cassava food (Codex Alimentarius Commission of FAO/WHO, 1988) is 10 ppm (or 10 mg/kg dry weight). However, levels below 100 ppm are considered safe in cassava chips and pellets imported into the European Union (EU) from Indonesia and Thailand for feeding of different classes of livestock. For pregnant stock only a consumption of up to 500 ppm cyanide breaks the placental barrier against thiocyanate transfer (Tewe, 1978). This hydrocyanic acid level is rarely encountered in fresh or dried cassava samples. Moreover, since balanced livestock rations only contain a proportion of energy, cassava is rarely fed at levels of more than 50 percent of the rations. Hydrocyanic acid levels above 250 ppm will rarely be encountered in practical cassava-based rations. It is important to note that levels of hydrocyanic acid in cassava leaves can be as high as 2 000 mg/kg of fresh leaves while chopping and drying reduces the level by at least 90 percent within 24 hours of exposure.

2.4 Production levels in the various regions of Africa

According to Nweke *et al.* (2002), the collaborative study on cassava in Africa (COSCA) revealed that between 1961 and 1999, total cassava production in Africa nearly tripled from 33 million tonnes per year from 1961 to 1965 to 87 million tonnes per year from 1995 to 1999, in contrast to the more moderate increases in Asia and Latin America. Most of the dramatic increase in cassava production in Africa was achieved in Ghana and Nigeria. In each of these countries, the production growth rate was greater than the rate of population growth. In other countries, D.R. of the Congo, Côte d'Ivoire, United Republic of Tanzania and Uganda, the increase in cassava production kept pace with population growth.

From 1961 to 1965, Nigeria produced only 7.8 million tonnes of cassava per year and was the fourth-largest producer in the world after Brazil, Indonesia and the D.R. of the Congo (FAOSTAT). From 1995 to 1999, Nigeria produced 30 million tonnes per year and became the largest producer worldwide; Ghana was only the seventh largest producer in Africa from 1961 to 1965 with an annual production of only 1.2 million tonnes. From 1995 to 1999, however, Ghana produced 7.2 million tonnes annually and advanced to the position of the third largest producer in Africa after Nigeria and the D.R. of the Congo.

The dramatic increase in cassava production in Ghana and Nigeria was achieved through an increase in both area and yield. In 1951, the average yield in Africa was between 5 and 10 tonnes/ha (Jones, 1959). The COSCA study showed that the average yield was between 10 and 15 tonnes/ha in Côte d'Ivoire, Democratic Republic of the Congo (D.R. of the Congo), Ghana, Nigeria, United Republic of Tanzania and Uganda. Cassava yield therefore increased in Africa in the early 1960s due mainly to the planting of high yielding varieties and the adoption of better agronomic practices. The average farm yield was highest in Nigeria with 14.7 tonnes/ha, followed by Ghana with 13.1 tonnes, Côte d'Ivoire, 10.8 tonnes, Uganda, 10.6 tonnes, United Republic of Tanzania, 10.5 tonnes and the D.R. of the Congo, 9.7 tonnes/ha.

Cassava production in South Africa is a fairly recent development coming with the advent of production of high quality starch from cassava on an industrial scale (Caysey, 2002 personal communication). The average yield on a 5 000 ha cassava farm in South Africa is presently 50 tonnes/ha at a production cost of US$20/tonne. Modern agronomic practices coupled with use of improved varieties and other inputs have made this model a reference point for potential of cassava on the continent.

2.5 Potential for use of cassava as animal feed in Africa

Of a total production of 87 million tonnes annually in Africa, only 6 percent of this is used in livestock production mainly in traditional systems. By contrast, in Latin America, 32.4 percent of its cassava is used for livestock feeding while in Asia, over 40 percent of its products is exported in the form of chips and pellets for the European Union livestock industry with another 2.9 percent used for domestic livestock production (International Fund for Agricultural Development - IFAD and Food and Agriculture Organization of the United Nations - FAO, 2000).

The share of African cassava production used as livestock feed is probably underestimated because cassava roots and leaves are fed to sheep, goat and pigs on small-scale farms in the cassava producing areas, either in fresh or cut-and-dried form (Nweke *et al.* 2002). Cassava production, sheep and rearing are highly complementary because cassava processing is carried out around homes, and sheep, goats and chicken are fed by-products of cassava processing.

African cassava pellets are presently not competitive in European livestock feed markets because of the high cost of production and transportation within Africa and Europe and because Africa has been an unreliable supplier of pellets (Philips, 1973). The rising cost of grains on the continent due to weather induced fluctuations, high foreign debts and currency devaluation has forced a number of countries in Africa to look inwards for alternatives to maize particularly for its livestock industry. In 1985 the Government of Nigeria banned the importation of maize and compelled livestock feed mills to look for local crop sources such as cassava. As a result, the proportion of total cassava production used as livestock feed increased from 3-10 percent from 1985 to 1990 (FAOSTAT). The Nigeria feed milling industry has therefore adjusted their facilities to utilize cassava chips as long as the price of cassava is competitive.

Presently, price considerations keep the usage of cassava low in the African livestock industry. However, with higher productivity expected from improved varieties and cost saving production and processing technologies, a surplus is anticipated that could lower the farm price of cassava. This scenario has led to growing interest among government authorities, the private sector and researchers in Africa on the improvement of processing and utilization of cassava for its livestock industry currently faced with a limited supply of raw materials for the feed industry. This has resulted in a continuous increase in the cost of production, causing a phenomenal rise in the unit cost of livestock products, which has become too expensive and unaffordable for the majority of the population of the continent. Cassava can play a significant role in stemming this tide of animal protein shortage.

3. LIVESTOCK SYSTEMS IN SUB-SAHARAN AFRICA

3.1 Production pattern

Livestock plays an important role in the economy of sub-Saharan Africa, providing sustenance as milk and meat, animal traction and transport, manure for crop production, cash income from sales of livestock products and a safety net of capital assets to face risks and misfortunes in harsh environments. The main categories of domestic livestock in tropical Africa are large ruminants (cattle and camels), small ruminants (sheep and goats), non-ruminant grazing animals (asses, mules and horses or equines, pigs and chickens). The numerical importance of ruminants within this group of cattle is apparent. In terms of livestock units, cattle account for three-quarters of the total livestock population.

The distribution of ruminant livestock in tropical Africa is uneven. East African has over one half of the total population, while the ruminant livestock herd in Central Africa accounts for little more than 3 percent of the total. A similar low figure holds for the coastal countries of West Africa. In terms of the individual countries, the Sudan and particularly Ethiopia stand out for their large ruminant livestock herds, while D.R. of the Congo, compared with its size, features very low numbers. The distribution of the equine population follows a similar though unidentical pattern to that of ruminants. Natural factors like the presence of tse-tse fly combined with historical and cultural factors play a role in their distribution. The pig population distribution is influenced by religion (particularly but not exclusively Islamic) taboos, which explain the low numbers in the Sahel countries, the Sudan and Ethiopia. The coastal countries of West Africa including Nigeria and Central Africa on the other hand have almost two-thirds of the total population. Their distribution follows relatively closely to that of the human population. The ratio ranges from one to two birds per person throughout tropical Africa. The higher figures tend to be found in the more humid countries. The population trends of different livestock species and their density per caput in the four regions of sub-Saharan Africa between 1991 and 2000 are shown in Tables 1-8 (FAOSTAT).

The population of different livestock species in four countries of West Africa namely: Burkina Faso, Côte d'Ivoire, Ghana and Nigeria are shown in Table 1 for the years 1991, 1995 and 2000. Numerically, Nigeria has a leading figure for each of the livestock species. The livestock population also increases for all species from 1991 to 2000. However as shown in Table 2, the population of each livestock species per caput for the same periods gives a different picture as Burkina Faso has the highest proportion of cattle to human population of between 0.24 and 0.59 while Nigeria is second with a proportion of between 0.16 and 0.18. A similar trend is observed for poultry population with the highest figure of 1.94 chicken/head in Burkina Faso for 2000.

The livestock population trend in the east Africa region shows a consistent increase between 1991 and 2000 (Table 3). The density of livestock per capita in this region is much higher than in West Africa. In particular, the sheep population per caput is highest in the Sudan at 1.5 per caput in 2000 (Table 4).

The livestock population as shown in Table 5 indicates that Cameroon and Chad have cattle populations of about 4 million with the D.R. of the Congo having about 1 million.

Poultry population is highest in Cameroon and the D.R. of the Congo with the least recorded in Chad. Livestock density per caput, as shown in Table 6 reveals that Chad has the highest cattle density/caput and the lowest is recorded in the D.R. of the Congo. For poultry, Cameroon has the highest density/caput increasing from 1.52 in 1991 to 2.02 in 2000.

The livestock population in South Africa showed an increasing trend from 1991 to 2000. The highest cattle population is recorded in South Africa followed by Madagascar (Table 7). Poultry is also highest in South Africa. The livestock density per caput in Table 8 shows Madagascar as having the highest figure for cattle and the lowest being in Malawi. Poultry density per caput is highest in South Africa and lowest in Malawi.

In most of Africa, livestock production is extensive. This applies to pastoral and agro pastoral systems in the arid and semi-arid zones, where rainfall patterns predict unreliable cropping and limit the support capacity of land for people and livestock. These systems are predominant over more than 30 percent of the land and include more than 40 percent of the cattle and small ruminants and all camels.

Livestock management is also extensive in higher rainfall areas with mixed farming systems, even where overall land use has intensified as a result of increasing population pressure. Livestock continues to rely on natural pastures, mostly communally owned, fallows and crop residues for feed and a few external inputs are applied to increase its productivity. More inputs into the subsystem occur primarily when direct or indirect monetary benefits present themselves, for example, milk sales and opportunistic fattening of stock in particular to exploit increased demand during religious festivals. Thus, it appears that while increasing population pressure intensified overall land use in a mixed system, the livestock subsystem remains extensive unless direct cash benefits occur that warrant the injection of purchased inputs and extra labour.

This pattern has largely influenced the distribution of subsistence (extensive) and commercial (intensive) production systems in different countries. For example, Nigeria livestock resources are still largely traditionally managed at over 85 percent of all species while commercially managed ones are only significant for poultry at 13.8 percent and to a lesser extent for pigs at 3.24 percent. The commercially (intensive) managed chickens and pigs are largely found in the more densely populated coastal areas of southern Nigeria.

3.2 Productivity

African indigenous breeds of cattle, sheep, goats, pigs and poultry are not very productive. By global standards figures of production per head are extremely low, lower than in any other region of the world (Jahnke, 1982). The breeds of livestock are largely characterized by poor growth rate, low fertility, poor feed utilization, small mature size and poor yields in terms of milk and eggs. Importation of exotic breeds has only had an impact on commercially raised domestic chickens and pigs in some countries.

3.3 Marketing

Livestock marketing in Africa is still rather primitive largely consisting of collection, redistribution and consumption markets with a wide array of middlepersons. Three main classes of producers can be recognized with their peculiar marketing abilities and constraints. These are:

1. The subsistence-oriented producers whose degree of marketing is limited to annual family needs and emergency sales of livestock during drought;
2. The semi-subsistence producers who are represented in the traditional urban producers; and
3. The commercial specialist producers who are represented by the intensive producers of poultry and pigs.

It is important to note that marketing is of particular importance for pastoral production systems in the arid zone. The arid zones constitute the source of the livestock flow. They are the extensive breeding grounds from which the marketing starts. Marketing poses particular problems in the dry area where distances are great and infrastructure is lacking

3.4 Livestock feeding

The bulk of livestock in Africa, being extensively managed, largely depends on fodder from rangelands. The problem of adequacy of fodder is higher in the arid and semi-arid zones which are the major producers of cattle; range livestock production systems, of which the pastoral systems are concentrated in the arid zone, while the ranching system, which is found in most ecological zones. The pasture in the rangelands is characterized by poor nutritive value due to their fibrousness. There is also extensive transhumance movement of cattle during the dry seasons of the year. In the more humid areas, livestock has access to some crop residues but these are not consistent and still become scarce during the dry season. Only in the intensive systems of commercial poultry and pig population are livestock fed adequate rations for satisfactory productivity when feed costs are affordable. Where opportunities of sales during festivities arise, ruminant stocks are fattened with additional feed inputs for such markets.

The bulk of the feed in the extensive production systems therefore lack adequate nutrients for satisfactory productivity. Supplemental feeding is critical in these systems. Acute shortage of feed also occurs in the intensive rearing systems due to escalating prices of maize and other feed ingredients thus raising the cost of livestock production.

3.5 Livestock diseases

In conjunction with inadequacy of feeding, disease burden largely explains the poor productivity and high mortality of stock. Pastoral production systems, which dominate tropical Africa livestock production, are particularly vulnerable to certain types of diseases. Thus, long treks and frequent intermingling of different groups of animals provide ideal opportunities for the extensive spread of rinderpest, anthrax, blackleg and contagious bovine pleura-pneumonia, the great infectious disease of Africa livestock. Exposure to wildlife en route and concentration of stock on river and lake shore grazing during the drier part of the year provide further opportunities for infection. With the advent of improved vaccines, most African countries treat herds effectively; however, the problem still lies in the motility of the herds and the extensive nature of the production systems. Lack of control over herds moving across national boundaries also aggravates the situation. The intensely managed poultry and pig also suffer from escalating costs of vaccines and unavailability of some which have resulted in wiping out complete national herds like the Africa Swine Fever which ravaged the swine industry in Africa in the last decade. The risk of disease outbreaks is therefore a disincentive for investing in livestock enterprises in tropical Africa.

Table 1. Human and livestock population in selected countries of West Africa (1991-2000)

Population	Nigeria	Ghana	Côte d'Ivoire	Burkina Faso
1991				
Human	85 953	15 138	12 582	9 008
Cattle	13 947 000	1m 144 787	1 108 000	3 937 200
Sheep	12 460 000	2 223 599	1 134 000	5 047 000
Goat	23 321 008	2 018 527	888 000	6 561 100
Pigs	3 410 000	473 946	360 000	505 900
Poultry	126 090 000	9 686 000	24 120 000	17 011 000
1995				
Human	99 278	17 297	14 385	10 270
Cattle	15 405 180	1 216 677	1 258 000	4 345 900
Sheep	14 000 000	2 010 147	1 282 000	5 850 900
Goat	24 500 000	2 204 150	1 002 000	7 459 400
Pigs	4 148 786	351 169	414 000	563 400
Poultry	N/A	N/A	N/A	N/A
2000				
Human	113 862	19 306	16 013 000	11 535
Cattle	N/A	N/A	N/A	N/A
Sheep	20 500 000	2 743 000	1 451 000	6 782 440
Goat	24 300 000	3 077 000	1 134 000	8 647 290
Pigs	4 855 000	324 000	336 000	622 493
Poultry	126 000 000	20 472 000	29 400 000	22 420 000

Source: FAOSTAT N/A = Data not available

Table 2. Livestock density per caput in selected countries of West Africa (1991-2000)

Livestock Species	Nigeria	Ghana	Côte d'Ivoire	Burkina Faso
1991				
Cattle	0.163	0.071	0.09	0.44
Sheep	0.145	0.15	0.091	0.560
Goat	0.27	0.13	0.07	0.73
Pigs	0.04	0.03	0.03	0.06
Poultry	1.5	0.64	1.72	1.89
1995				
Cattle	0.16	0.07	0.09	0.423
Sheep	0.14	0.12	0.091	0.57
Goat	0.25	0.13	0.07	0.73
Pigs	0.042	0.02	0.03	0.055
Poultry	N/A	N/A	N/A	N/A
2000				
Cattle	N/A	N/A	N/A	N/A
Sheep	0.18	0.14	0.09	0.588
Goat	0.213	0.16	0.071	0.750
Pigs	0.043	0.017	0.02	0.054
Poultry	1.11	1.1	1.84	1.944

Source: FAOSTAT N/A = Data not available

Table 3. Human and livestock population in selected countries of East Africa (1991-2000)

Population	Kenya	Uganda	Tanzania	Ethiopia	Sudan
1991					
Human	23 514	17 245	26 043	50 612	24 818
Cattle	13 793 000	4 913 200	13 046 855	30 000 000	21 027 800
Sheep	9 046 610	780 000	3 556 985	22 960 000	20 700 000
Goat	10 186 090	4 710 000	8 525 908	17 200 000	15 276 800
Pigs	128 168	1 160 000	320 000	19 000	-
Poultry	25 228 011	18 960 000	20 500 000	57 800 000	32 263 000
1995					
Human	27 315	20 108	30 868	N/A	27 952
Cattle	13 566 700	5 233 000	13 888 000	29 825 030	N/A
Sheep	7 921 890	924 000	3 970 000	21 750 000	30 077 000
Goat	10 395 237	5 545 000	9 700 000	16 750 000	37 180 000
Pigs	230 600 100	1 343 000	340 000 000	21 000 000	35 215 000
Poultry	N/A	N/A	N/A	N/A	N/A
2000					
Human	30 699	6 223 300	35 119	62 908	31098
Cattle	N/A	N/A	N/A	N/A	N/A
Sheep	7 000 000	1 050 000	4 200 000	22 500 000	46 095 000
Goat	9 600 000	6 200 000	9 950 000	17 000 000	38 508 000
Pigs	315 400	1 550 000	350 000	25 000	N/A
Poultry	31 847 000	25 000 000	27 798 000	55 600 000	37 000 000

Source: FAOSTAT N/A = Data not available

Table 4. Livestock density per caput in selected countries of East Africa (1991-2000)

Livestock Species	Kenya	Uganda	Tanzania	Ethiopia	Sudan
1991:					
Cattle	0.59	0.3	0.5	0.6	0.85
Sheep	0.384	0.05	0.14	0.5	0.84
Goat	0.432	0.27	0.33	0.34	0.62
Pigs	0.005	0.07	0.02	0.0004	-
Poultry	1.1	1.1	1.0	1.14	1.3
1995:					
Cattle	0.5	0.26	0.5	N/A	N/A
Sheep	0.29	0.05	0.13	N/A	1.1
Goat	0.4	0.28	0.314	N/A	1.33
Pigs	0.0084	0.07	0.01	N/A	1.26
Poultry	N/A	N/A	N/A	N/A	N/A
2000:					
Cattle	N/A	N/A	N/A	N/A	N/A
Sheep	0.23	0.05	0.12	0.4	1.5
Goat	0.31	0.27	0.28	0.3	1.24
Pigs	0.01	0.07	0.04	0.0004	N/A
Poultry	1.04	0.001	0.8	0.9	1.2

Source: FAOSTAT N/A = Data not available

Table 5. Human and livestock population in selected countries of Central Africa (1991-2000)

Indices Population	Cameroon	Congo, D.R. of	Chad
1991			
Human	11 614	36 999	5 827
Cattle	4 697 000	1 534 700	4 297 300
Sheep	3 500 000	27 000	1 925 710
Goats	3 520 000	3 849 900	2 837 820
Pigs	1 364 000	1 050 000	13 830
Poultry	17 600 000	27 490 000	4 000 000
1995			
Human	13 273	44 834	6 735
Cattle	4 650 000	1 113 140	4 746 400
Sheep	3 400 000	1 018 610	2 219 000
Goats	3 620 000	4 310 410	3 271 000
Pigs	1 000 000	1 084 410	17 654
Poultry	N/A	N/A	N/A
2000			
Human	14 876	50 948	7 885
Cattle	N/A	N/A	N/A
Sheep	3 753 000	924 924	2 401 960
Goats	4 410 000	4 131 231	5 240 110
Pigs	1 346 000	1 048 716	22 000
Poultry	30 000 000	21 559 000	4 900 000

Source: FAOSTAT N/A = Data not available

Table 6. Livestock population per caput in selected countries of Central Africa (1991-2000)

Indices Population	Cameroon	Congo, D.R. of	Chad
1991			
Cattle	0.4	0.04	0.74
Sheep	0.3	0.03	0.33
Goats	0.3	0.11	0.5
Pigs	0.12	0.03	0.0024
Poultry	1.52	0.74	0.7
1995			
Cattle	0.35	0.003	0.71
Sheep	0.26	0.023	0.33
Goats	0.27	0.1	0.49
Pigs	0.08	0.024	0.0026
Poultry	N/A	N/A	N/A
2000			
Cattle	N/A	N/A	N/A
Sheep	0.25	0.02	0.31
Goats	0.30	0.08	0.67
Pigs	0.09	0.021	0.003
Poultry	2.02	0.423	0.62

Source: FAOSTAT N/A = Data not available

Table 7. Human and livestock population in selected countries of South Africa (1991-2000)

Indices population	Malawi	Zambia	Zimbabwe	South Africa	Madagascar
1991					
Human	9434	8 049	10 241	36 376	11 956
Cattle	835 550	2 878 000	6 407 000	13 500 000	10 254 000
Sheep	147 600	60 000	599 000	32 665 008	737 000
Goats	856 510	534 000	2 540 000	6 100 000	1 256 000
Pigs	233 110	295 000	303 000	1 532 000	1 430 800
Poultry	11 500 000	15 700 000	12 000 000	87 000 000	13 388 000
1995					
Human	10 020	9 218	11 475	40 033	13 789
Cattle	690 000	3 000 000	4 500 000	13 015 345	10 309 000
Sheep	100 000	74 000	487 000	28 748 326	821 000
Goats	1 100 000	650 000	2 615 000	6 456 789	1 399 000
Pigs	247 319	300 000	277 000	1 627 985	1 592 000
Poultry	N/A	N/A	N/A	N/A	N/A
2000					
Human	11 308	10 421	12 627	43 309	15 970
Cattle	N/A	N/A	N/A	N/A	N/A
Sheep	105 000	140 000	530 000	28 550 716	800 000
Goats	1 450 000	1 249 000	2 790 000	6 706 104	1 370 000
Pigs	240 000	330 000	275 000	1 555 595	900 000
Poultry	15 000 000	29 000 000	16 000 000	119 000 000	20 000 000

Source: FAOSTAT N/A = Data not available

Table 8. Livestock density per caput in selected countries of South Africa (1991-2000)

Indices population	Malawi	Zambia	Zimbabwe	South Africa	Madagascar
1991					
Cattle	0.1	0.36	0.62	0.37	0.86
Sheep	0.02	0.0075	0.06	0.9	0.062
Goats	0.01	0.07	0.24	0.17	0.11
Pigs	0.025	0.04	0.03	0.04	0.12
Poultry	1.2	1.96	1.15	2.4	1.12
1995					
Cattle	0.07	0.33	0.39	0.325	0.75
Sheep	0.01	0.008	0.04	0.72	0.06
Goats	0.11	0.07	0.23	0.161	0.10
Pigs	0.025	0.033	0.024	0.04	0.12
Poultry	N/A	N/A	N/A	N/A	N/A
2000					
Cattle	N/A	N/A	N/A	N/A	N/A
Sheep	0.01	0.013	0.04	0.7	0.05
Goats	0.13	0.12	0.22	0.155	0.09
Pigs	0.02	0.03	0.022	0.036	0.06
Poultry	1.33	2.8	1.27	2.75	1.3

Source: FAOSTAT N/A = Data not available

4. INSTITUTIONAL SUPPORT FOR THE LIVESTOCK SECTOR

4.1 Government and non-governmental

The role of government in livestock development on the African continent has been largely in the area of policy formulation to assist producers to accelerate production at costs that consumers can afford. Strategies to achieve this objective have centered on the following:

- ecological specialization in livestock production;
- sedentarization particularly of pastoralists;
- provision of feeds and fodder improvement;
- breeding to improve indigenous stock;
- provision of veterinary services to alleviate animal health problems; and
- provision of domestic credit.

The dismal failure in the livestock sector in post-independent Africa can be largely blamed on inconsistent government policies and gross under funding of the sector. Even in the colonial period some key developments like the diary industry in Kenya was undertaken largely at the initiative of the then European farmers who created a structure of services through the government and through their own independent efforts (Jahnke, 1982). The persistently woeful performance of this sector in many African countries reflects the lack of sustained governmental support for privately led initiatives.

Extension services in livestock production in Africa is in its infancy because even with the creation of World Bank-assisted agricultural development projects in Nigeria and other African countries, livestock extension was not ranked as important compared with the crop production sector. Hence, it is only in the last decade that the structure for incorporating such into extension services has become notable. Presently spiral inflation and unfavourable interest rates have ostracized the small-scale livestock producer from financed credits. The high risks involved in livestock production further discourage credit institutions to give necessary support to the sector on the continent. With primitive marketing infrastructure and inconsistent pricing policy, the livestock producer is left with the individuals' ability to discern and take advantage of opportunities of markets particularly during festivals to dispose products.

With huge funding assistance from foreign organizations being wasted when executed through government agencies, it has become imperative to find reliable non-governmental institutions with healthy track records to initiate efforts on livestock development in farming communities on the continent. This is in its infancy and significant efforts are still largely restricted to the crop production sector.

4.2 Research centres and universities

Most research centres and universities offering training in agriculture are ill equipped for solving problems of livestock production on the continent. With poor infrastructure, inadequate research personnel, unattractive remuneration and absence of dynamic transfer of information between researchers and producers, the impact of researchers on the sector has been minimal. Research undertaken however, covers the areas of forage development, livestock nutrition and disease, local genetic resources improvement and livestock housing. Although many African countries have programmes for livestock science and technology, in many cases these are only blue prints for development with little legislative clout and insufficient budgetary backing to achieve their stated goals.

Special mention must be made of the research focus of the International Livestock Research Institute (ILRI). The basic thrust of this institute is cattle, milk and meat; that is to increase the sustainable output of milk and meat from cattle in the mixed crop-livestock smallholder production systems of sub-Saharan Africa. ILRI's research programmes focus on these production systems because they appear to offer the best opportunities for increasing protein output and hence food production as a whole in the foreseeable future. Specific interventions and models adopted include alley farming, fodder banks, crop residue utilization and feed supplementation. A thrust of holistic utilization of crops and residues for production of ruminants and monogastric animals is a recently added dimension. Institutions in partnership with the International Livestock Research Institute (ILRI) in selected countries of sub-Saharan Africa are presented in Table 9.

Table 9. Institutions in partnership with the International Livestock Research Institute (ILRI) in selected countries of sub-Saharan Africa

COUNTRIES	INSTITUTIONS
WEST AFRICA 1. NIGERIA	i. Ahmadu Bello University ii. Balyesa State Agriculture Development Project iii. Federal Ministry of Agriculture and Rural Development iv. National Animal Production Research Institute v. National Root Crops Research Institute vi. Rivers State Institute of Agriculture Research and Training vii. Rivers State University of Science and Technology viii. University of Ibadan ix. University of Agriculture at Abeokuta
2. GHANA	i. Agricultural Research Institute ii. Animal Research Institute iii. Ministry of Agriculture iv. Savanna Agricultural Research Institute v. University of Ghana vi. University of Science and Technology
3. COTE D'IVOIRE	i. Anader ii. Centre ivoirien de recherche économique et sociale iii. Centre national de recherche agronomique iv. Institut national polytechnique Houphouët Boigney v. Ministère de l'agriculture et des ressources animales vi. Project de lutte contre la trypanosomiase animale et les vecteurs
4. BURKINA FASO	i. Institut de l'environement et de recherche agricole ii. Institut économique de recherche iii. Ministère des ressources animales iv. Programme sahélien burkinabé v. Service provincial des ressources animales vi. Université de Ouagadougou
EAST AFRICA 5. KENYA	i. Agricultural Information Centre ii. Agricultural Research Foundation iii. Central Bureau of Statistics iv. Department of Resource Surveys and Remote Sensing

	v. Egerton University vi. Institute of Molecular and Cell Biology-Africa vii. Institute of Policy Analysis Research viii. Kenya Agricultural Research Institute (KARI) ix. Kenya Trypanosomicism Research Institute x. Kenyatta University xi. Koyiaki Group Rural xii. Lemek Group Rural xiii. Ministry of Agriculture and Rural Development xiv. Ministry of Environment xv. Olgulului Group Rural xvi. Selengai Group Ranch xvii. University of Nairobi
6. UGANDA	i. Livestock Health Research Institute ii. Makerere University iii. Ministry of Agriculture iv. National Agricultural Research Organization v. Uganda Wildlife Authority
7. TANZANIA	i. Animal Disease Research Institute ii. Livestock Production Research Institute iii. Ministry of Agriculture and Cooperatives iv. Sehan Agricultural Research Institute v. Sokoine University of Agriculture vi. Tanzania National Research Bureau
8. ETHIOPIA	i. Addis Ababa University ii. Alemaya University of Agriculture iii. Amhora Bureau of Agriculture iv. Ethiopia Agricultural Research Organization v. Mekelle University vi. Ministry of Agriculture vii. Oromiya Agricultural Development of Bureau viii. Tigray Bureau of Agriculture
9. SUDAN	i. Animal Resource Research Corporation ii. Ministry of Agriculture, Natural and Animal Resources
CENTRAL AFRICA 10. CAMEROON	i. Animal Science and Veterinary Research Institute ii. Discharge University iii. Institute de recherche agronomique
11. CONGO, D.R. of	i. Bureau central de la trypanosomiase, d'étude et de recherche agronomiques ii. Instistut national d'étude et de recherche agronomiques iii. Laboratoire vétérinaire de Kinshasa iv. Université de Kinshasa
SOUTH AFRICA 12. MALAWI	i. University of Malawi
13. ZAMBIA	i. Ministry of Agriculture, Food and Fisheries ii. Ministry of Science, Technology and Vocational Training iii. University of Zambia
14. ZIMBABWE	i. Central Veterinary Laboratory ii. Department of Research and Specialist Services iii. Veterinary Department iv. University of Zimbabwe v. Zimbabwe National Parks
15. SOUTH AFRICA	i. Agricultural Research Council ii. Agricultural Research Council-Animal Nutrition Institute iii. Irene Animal Production Institute iv. Onderste poort Veterinary Institute v. University of Pretoria vi. University of Stellenbosch

16. MADAGASCAR	i. Ministère de la recherche scientifique ii. Univeristé d'Antananarivo

5. CURRENT AND EMERGING TRENDS IN THE LIVESTOCK FEEDING SECTOR

5.1 West Africa

The production of cereals, particularly maize, cassava, other roots, soybeans and groundnuts in this region is shown in Table 10. Nigeria leads in terms of production of the listed crops. It is particularly the leading producer of cassava for the region and globally with a production of 32 586 000 tonnes in 2000. Ghana, Côte d'Ivoire and Burkina Faso record 8 107 000, 1 673 000 and 2 000 metric tonnes respectively for the same period. The import and export figures for those crops as shown in Table 11 show a consistent but low import of cereals and particularly maize. Cassava import is minimal and it was non-existent by 2000. Cassava is also not exported in any of the listed countries except for Côte d'Ivoire which recorded an export of 1 000 metric tonnes of cassava in 1995. The domestic utilization of these crops as shown in Table 12 reveals a rising trend in the use of cassava for livestock feed in Nigeria from 1 162 000 metric tonnes in 1991 to 1 629 000 metric tonnes in 2000. For Ghana cassava usage also increased from 114 000-162 000 metric tonnes for the same period. Côte d'Ivoire recorded 74 000 metric tonnes for feed in 1991 increasing to 84 000 tonnes in 2000. Burkina Faso showed no indication for use of cassava in livestock feed for the ten year study period. The quantity of maize used for livestock feed in Nigeria fluctuated between 1 642 000 and 2 026 000 tonnes. A similar trend is observed in Ghana while Côte d'Ivoire showed an increase from 60 000 tonnes in 1995 to 90 000 tonnes in 2000. Burkina Faso however, recorded no usage of cereals or storage roots in livestock feed indicating a largely extensive system of livestock rearing with insignificant compound feed usage.

Expressing feed usage as a percentage of total production (Table 13) shows that maize used for livestock feed stands at 20 percent of total domestic production while cassava stood at 5 percent of the total in Nigeria. In Ghana maize and cassava is 6 and 2 percent of production respectively. Côte d'Ivoire records about 10 and 5 percent respectively while in Burkina Faso maize and cassava were not used for livestock feeding.

It is noteworthy that crop wastes as shown in Table 13 indicate a substantial portion of crop produced which is wasted on farm or as agro-industrial by-products in all the countries being studied. Cassava wastes in Nigeria, Ghana Côte d'Ivoire and Burkina Faso represent 52, 44, 5 and 0 percent respectively, for 1991 and correspond to 52, 38.3, 5 and 0 percent respectively, for 2000 as shown in Table 13. Some quantities of these wastes might have been used for animal feeding as supplements. However, they show potential for their incorporation into feeds in the respective countries.

Table 10. Production (‘000 metric tonnes) of cereals, root crops and oil seeds in selected West African countries (1991-2000)

Indices	Nigeria	Ghana	Côte d’Ivoire	Burkina Faso
Crop Production				
1991				
Cereals	17 541	1 386	1 020	2 242
Maize	5 810	932	497	325
Cassava	6 004	5 701	1 785	3
Roots	829	1 297	312	36
Soybean	145	-	4	0
Groundnut	953	47	91	69
1995				
Cereals	21 250	1 730	1 155	2 280
Maize	6 931	1 034	552	212
Cassava	31 404	6 612	1 608	2
Roots	1 182	1 383	246	64
Soybean	287	-	3	3
Groundnut	1 105	118	100	126
2000				
Cereals	21 965	1 628	1 583	2 252
Maize	5 609	1 013	693	726
Cassava	32 586	8 107	1 673	2
Roots	3 910	1 625	365	55
Soybean	430	-	3	3
Groundnut	2 050	140	101	118

Source: FAOSTAT

Table 11. Crop import and export (‘000 metric tonnes) in selected West African countries (1991-2000)

Indices	Nigeria	Ghana	Côte d’Ivoire	Burkina Faso
Crop Imports (Export)				
1991				
Cereals	832 (0)	44 (0)	676 (36)	227 (0)
Maize	0 (0)	20 (0)	23 (30)	50 (0)
Cassava	2 (0)	0 (1)	0 (0)	- (0)
Roots	0 (0)	0 (0)	- -	- (0)
Soybean	0 (0)	- -	0 (0)	0 (1)
Groundnut	0 (0)	0 (0)	3 (0)	0 (5)
1995				
Cereals	1 038 (77)	279 (0)	739 (6)	139 (3)
Maize	2 (0)	16 (0)	22 (2)	22 (0)
Cassava	2 (0)	0 (-)	0 (1)	-3 (-)
Roots	- (0)	0 (0)	- (0)	1 (0)
Soybean	0 (0)	- (-)	0 (0)	0 (0)
Groundnut	0 (0)	0 (0)	4 (1)	0 (-)
2000				
Cereals	3 098 (29)	501 (3)	840 (21)	212 (13)
Maize	7 (20)	7 (1)	20 (3)	2 (2)
Cassava	- (0)	0 (8)	0 (0)	- -
Roots	0 (0)	0 (0)	- (5)	1 (0)
Soybean	3 (0)	0 (0)	0 (0)	- -
Groundnut	4 (0)	0 (0)	0 (1)	0 (0)

Source: FAOSTAT. Export figures are in parenthesis

Table 12. Utilization of crops ('000 metric tonnes) for livestock feed and their wastages in selected West African countries (1991-2000)

Indices	Nigeria	Ghana	Côte d'Ivoire	Burkina Faso
Feed/wastes				
1991				
Cereals	1 642 (3 496)	56 (238)	60 (160)	(207)
Maize	1 162 (1 229)	56 (155)	52 (85)	(25)
Cassava	1 300 (3 448)	114 (2 501)	74 (74)	(0)
Roots	- (249	- (260)	- (34)	(4)
Soybean	- (29)	- -	- (0)	(0)
Groundnut	- (65)	- (48)	0 (9)	(3)
1995				
Cereals	2 026 (4 389)	63 (293)	62 (205)	- (207)
Maize	1 386 (1 467)	63 (172)	55 (91)	- (21)
Cassava	21 570 (16 241)	132 (2701)	80 (80)	- (0)
Roots	0(355)	- -	- -	- (6)
Soybean	0 (57)	- (-)	- (10)	- (2)
Groundnut	0 (74)	- (4)	- (0)	- (0)
2000				
Cereals	1 843 (4 511)	61 (277)	90 (271)	- (216)
Maize	1 122 (1 187)	61 (169)	81 (134)	- (43)
Cassava	1 629 (16 852)	162 (3101)	84 (84)	- (0)
Roots	- (1173)	162 (3101)	- (56)	- (5)
Soybean	- (87)	- (-)	- (0)	- (0)
Groundnut	- (139)	11 (4)	- (9)	- (7)

Figure ('000 metric tonnes) for wastes are in parenthesis
Source: FAOSTAT

Table 13. Percentage utilization of crops for livestock feed and their wastages in selected West African countries (1991-2000)

Indices	Nigeria	Ghana	Côte d'Ivoire	Burkina Faso
1991				
Cereals	4.4 (20)	4 (17.1)	6 (16)	- (9.2)
Maize	20 (21.2)	6 (15)	10.5 (17.1)	- (7.7)
Cassava	5 (52)	2 (44)	5 (5)	- (0)
Roots	- (30)	- (20)	- (10)	- (11.1)
Soybean	- (20)	- -	- (0)	- (0)
Groundnut	- (7)	- (49)	0 (9.9)	- (4.3)
1995				
Cereals	9.5 (21)	4 (17)	5.4 (17)	- (9.1)
Maize	20 (21)	6 (17)	9.9 (16.5)	- (9.9)
Cassava	5 (52)	2 (41)	5 (5)	- (0)
Roots	0 (30)	- -	- -	- (9.4)
Soybean	0 (20)	- -	- (4)	- (66.6)
Groundnut	0 (7)	- (3.4)	- (0)	- (0)
2000				
Cereals	8.4 (20.5)	4 (17)	5.7 (17.1)	- (9.6)
Maize	20 (52)	6 (17)	11.7 (19.3)	- (6)
Cassava	5 (52)	2 (38.3)	5 (5)	- (0)
Roots	- (30)	- -	- (14.5)	- (9)
Soybean	- (20.2)	- -	- (0)	- (0)
Groundnut	- (6.8)	8 (3)	- (8.9)	- (6)

Percentages for wastes are in parenthesis
Source: FAOSTAT

5.2 East Africa

Crop production as shown in Table 14 indicates United Republic of Tanzania as the leading producer of cassava in the region reaching 4 152 000 metric tonnes in 2000 while the Sudan produced at least 9 000 metric tonnes for the same period. Utilization of cassava for livestock feed (Table 16) shows that only United Republic of Tanzania and Uganda used this root crop for livestock feeds with Uganda reaching 1 342 000 metric tonnes in 1995 and decreasing by about half to 556 000 metric tonnes in 2000. Maize utilization for feed shows United Republic of Tanzania leading with usage of 130 000 in 2000. No maize was used for feed production in Kenya for the same period although other cereals totalling 114 000 tonnes were used. When expressed as a percentage of total production, Uganda recorded the highest at between 25-27 percent of cassava being used for feed between 1991 and 2000. For United Republic of Tanzania cassava used was only 0.5 percent of total production. Ethiopia, Kenya and the Sudan depend solely on cereals as an energy component of feed with levels of maize usage ranging from 3.6 percent of production in Ethiopia in 2000 to 3.8 percent of production in the Sudan for the same period. The trend in maize usage in the region shows a decline between 1991 and 2000 (Table 17). The percentage of production that is wasted shows that cassava figures ranged from 2.66 percent in United Republic of Tanzania to 10.1 percent in Uganda for 2000. Maize wastage also gives a similar trend in all countries of the region. The percentages recorded as waste for maize and cassava are lower than those in West Africa as cited earlier.

5.3 Central Africa

Crop production (Table 18) shows Cameroon as the leading producer of maize and cassava followed by Chad and lastly the D.R. of the Congo in this region. Soybean production is nil in the region while production of groundnut is highest in Chad followed by Cameroon and lastly by the D.R. of the Congo. Import and export of these commodities (Table 19) show that only maize but not cassava is imported by these three countries. Other roots are also exported: 1 000 metric tonnes in the D.R. of the Congo and only 1 000 metric tonnes of soybeans in Cameroon. Export trend shows a reduction in cereal export in the Cameroon from 3 000 in 1999 to 2 000 metric tonnes in 2000. No significant export for maize, cassava and the pulses occurred in the three countries for the ten year study period.

Utilization of these commodities for livestock feed in the three countries shows an interesting trend (Table 20). For the Cameroon, cassava usage for livestock feed far exceeds that of maize with the quantity fluctuating between 150 000 and 162 000 metric tonnes as compared with maize recording 5 000 metric tonnes for the ten year period. Usage of cassava in the D.R. of the Congo was 2 000 metric tonnes as compared with zero usage of maize for the same period. Similarly for Chad cassava usage was between 13 000 and 17 000 metric tonnes as compared with 3 000-6 000 tonnes for maize during the same period. Soybeans and groundnut were not recorded for use as livestock feed in the three countries.

Wastage of cassava in Cameroon, the D.R. of the Congo and Chad reveal 15, 2.2 and 5.2 percent wastes of production for cassava, respectively in 1991. For 2000 wastage was

15, 10.9 and l5 percent of production as shown in Table 21. These show high potentials for cassava usage particularly in the Cameroon.

Table 14. Production ('000 metric tonnes) of cereals, root crops and oil seeds in selected east African countries (1991-2000)

Crop production	Kenya	Uganda	Tanzania	Ethiopia	Sudan
1991					
Cereals	2 757	4 637	3 569	1 556	N/A
Maize	2 340	61	2 332	567	N/A
Cassava	761	8	7 460	3 229	N/A
Roots, other	10	N/A	N/A	N/A	N/A
Soybean	N/A	N/A	2	59	N/A
Groundnuts	12	126	49	101	N/A
1995					
Cereals	2 644	3 330	3 802	2 076	9 691
Maize	2 200	53	2 551	1 096	3 306
Cassava	950	10	5 758	4 966	N/A
Roots, other	10	N/A	N/A	N/A	3 480
Soybean	N/A	N/A	2	120	25
Groundnuts	21	663	52	97	10
2000					
Cereals	3 255	3 305	4 552	2 004	6 740
Maize	2 699	21	2 874	913	1 990
Cassava	840	9	5 969	2 224	N/A
Roots, other	10	N/A	N/A	N/A	3 200
Soybean	N/A	N/A	2	79	22
Groundnuts	8	517	50	101	6

Source: FAOSTAT N/A = Data not available

Table 15. Crop import and export ('000 metric tonnes) in selected east African countries (1991-2000)

Export/import	Kenya	Sudan	Tanzania	Uganda	Ethiopia
1991					
Cereals	325 (53)	1 229 (0)	149 (7)	32 (34)	-
Maize	0 (21)	15 (0)	2 (7)	0 (33)	-
Cassava	0 (0)	- -	0 (164)	0 (0)	-
Roots, other	0 (0)	- -	- -	- -)	-
Soybean	3 (0)	- -	0 (1)	0 (2)	-
Groundnuts	0 (0)	0 (7)	0 (17)	0 (0)	-
1995					
Cereals	1 186 (29)	868 (26)	500 (25)	220 (16)	347 (221)
Maize	417 (7)	21 (0)	55 (10)	19 (9)	12 (0)
Cassava	1 (0)	- -	0 (2)	2 (0)	- -
Roots, other	1 (0)	- -	0 (0)	0 (0)	- -
Soybean	4 (0)	- -	0 (0)	0 (0)	0 (-)
Groundnuts	1 (0)	0 (9)	0 (0)	0 (0)	- (0)
2000					
Cereals	347 (221)	408 (349)	235 (0)	164 (103)	649 (35)
Maize	41 (140)	0 (12)	81 (0)	61 (88)	25 (0)
Cassava	0 (0)	- -	0 (15)	0 (0)	- -
Roots, other	0 (0)		- -	0 (0)	- -
Soybean	0 (0)		0 (0)	5 (4)	0 (-)
Groundnuts	0 (0)	0 (5)	0 (0)	0 (0)	- (-)

Source: FAOSTAT
Export figures are in parenthesis

Table 16. Utilization of crops ('000 metric tonnes) and their wastage in selected east African countries (1991-2000)

Food/wastage	Kenya	Sudan	Tanzania	Uganda	Ethiopia
1991					
Cereals	105 (96)	96 (214)	155 (337)	160 (157)	NA
Maize	90 (69)	- (0)	140 (236)	65 (77)	NA
Cassava	- (23)	- (1)	37 (377)	807 (320)	NA
Roots, other	- (1)	- -	- -	- -	NA
Soybean	- -	- -	- (0)	- (3)	NA
Groundnuts	- (1)	- (14)	- (2)	- (7)	NA
2000					
Cereals	98 (424)	112 (212)	136 (285)	202 (214)	120 (546)
Maize	80 (384)	2 (5)	120 (165)	111 (133)	120 (166)
Cassava	- (28)	- (1)	29 (153)	1 342 (500)	- -
Roots, other	- (1)	- -	- -	- -	- (348)
Soybean	- -	- -	- (0)	- (6)	- (1)
Groundnuts	- (1)	- (69)	- (3)	- (7)	- (0)
1995					
Cereals	114 (114)	82 (214)	154 (700)	198 (199)	100 (382)
Maize	0 (-)	2 (4)	130 (553)	95 (112)	100 (116)
Cassava	- (25)	- (1)	30 (142)	556 (222)	- -
Roots, other	- (1)	- -	- -	- -	- (320)
Soybean	- -	- -	- (0)	- (4)	- (1)
Groundnuts	- (0)	- (66)	- (3)	- (7)	- (0)

Source: FAOSTAT

Figures ('000 metric tonnes) for wastes are in parenthesis

Table 17. Percentage utilization of crops for livestock feed and their wastages in selected east African countries (1991-2000)

Export/import	Kenya	Sudan	Tanzania	Uganda	Ethiopia
1991					
Cereals	4 (3.5)	7.8 (17.4)	4.3 (9.5)	10.3 (10)	NA
Maize	3.9 (3)	- (0)	6 (10.1)	11.5 (13.6)	NA
Cassava	- (3)	- (12.5)	0.5 (5.1)	25 (10)	NA
Roots, other	- (10)	- -	- -	- -	NA
Soybean	- (-)	- -	- (0)	- (5.1)	NA
Groundnuts	- (8.3)	- (11.1)	- (4.1)	- (7)	NA
1995					
Cereals	35 (35)	2.5 (6.5)	3 (15.4)	10 (10)	1.5 (6%)
Maize	0 (-)	9.5 (24)	5.0 (1.9)	10.4 (12.3)	5 (6)
Cassava	- (3)	- (11.1)	0.5 (3)	25 (10)	- -
Roots, other	- (10)	- -	- -	- -	- (10)
Soybean	- -	- -	- (0)	- (5.1)	- (5)
Groundnuts	- (0)	- (13.3)	- (6)	- (3)	- (0)
2000					
Cereals	4 (16)	3.4 (6.4)	3.6 (7.5)	9.7 (10.3)	1.24 (5.6)
Maize	0 (17.5)	3.8 (4)	5 (6.5)	10.1 (12.1)	3.6 (5)
Cassava	- (3)	- (10)	0.5 (2.66)	27 (10.1)	- -
Roots, other	- (10)	- -	- (-)	- -	- (10)
Soybean	- (-)	- -	- (0)	- (5)	- (4)
Groundnuts	- (5)	- (10.4)	- (5.8)	- (7.2)	- (0)

Source: FAOSTAT

Percentages for wastes are in parenthesis

Table 18. Production ('000 metric tonnes) of cereals, root crops and oil seeds in selected countries of Central Africa (1991-2000)

Indices	Cameroon	Congo, D.R. of	Chad
1991			
Cereals	483	6	773
Maize	495	5	48
Cassava	1 622	585	270
Roots, other	548	32	30
Soybean	0	-	-
Groundnut	66	19	161
1995			
Cereals	1 168	9	881
Maize	618	8	63
Cassava	1 780	747	268
Roots, other	750	40	38
Soybean	0	-	
Groundnut	82	19	205
2000			
Cereals	1 388	7	1 133
Maize	850	6	87
Cassava	1 500	828	342
Roots, other	541	35	38
Soybean	0	-	
Groundnut	66	16	233

Source: FAOSTAT

Table 19. Crop import and export (000 metric tonnes) in selected countries of Central African (1991-2000)

Indices	Cameroon	Congo, D.R. of	Chad
1991			
Cereals	326 (31)	122 (0)	73 (0)
Maize	22 (0)	0 (-)	0 (-)
Cassava	0 (0)	0 (0)	- (-)
Roots, other	0 (0)	0 (-)	0 (-)
Soybean	0 (0)		
Groundnut	0 (0)	0 (0)	0 (0)
1995			
Cereals	353 (1)	141 (0)	43 (0)
Maize	22 (0)	4 (-)	4 (-)
Cassava	0 (0)	0 (1)	- (-)
Roots, other	0 (4)	1 (-)	0 (-)
Soybean	0 (0)		
Groundnut	0 (0)	1 (0)	0 (0)
2000			
Cereals	417 (2)	230 (0)	52 (0)
Maize	25 (0)	12 (-)	0 (-)
Cassava	0 (1)	0 (1)	- (-)
Roots, other	0 (7)	1 (-)	0 (-)
Soybean	1 (0)	0 (-)	
Groundnut	0 (0)	0 (0)	0 (0)

Source: FAOSTAT
Export figure are in parenthesis

5.4 South Africa

Production of cassava (Table 22) shows an increasing trend over the period 1991 to 2000 in all countries. Madagascar recorded highest production figures of 2 307 000 metric tonnes in 1991 and similar figures up to 2000. Cassava has recently become popular in South Africa with a total of 1 323 000 metric tonnes in 1991. Cassava production in Zambia is higher than in Malawi and Zimbabwe (Table 22). Importation of cereals particularly maize was on the increase in all countries between 1991 and 1995. By 2000 however, cereal/maize importation had dropped considerably except in Madagascar and Zimbabwe. Utilization of maize and cassava for feed as shown in Table 24 reveals that only maize but no cassava is used for livestock feed in Malawi, South Africa, Zambia and Zimbabwe. In Madagascar a tremendous proportion of cassava is in use for livestock feed and was much higher than maize used in the period 1991 to 2000. Expressed as a percentage of production, cassava as feed represents 10 percent of total production for the ten-year period (Table 25); maize on the other hand represents about 5 percent of total production used for feed. Cassava wastage in Madagascar represented 8.9 percent of production in 1991 declining to 3.1 percent in 2000. Some potential for use of cassava in Malawi, Zambia and Zimbabwe exists as wastage constitutes between 5 and 20 percent of production in these countries. With the large plantation of cassava cultivated in South Africa primarily for starch production, the pulp waste and peel from the industry have potential for livestock feeding in that country.

Table 20. Utilization of crops ('000 metric tonnes) for livestock feed and their wastages in selected countries of Central Africa (1991-2000)

Indices	Cameroon	Congo, D.R. of	Chad
1991			
Cereals	5 (67)	0 (3)	14 (90)
Maize	5 (42)	- (0)	3 (5)
Cassava	162 (243)	2 (13)	14 (14)
Roots, other	112 (130)	- (-)	- (4)
Soybean	- (-)		
Groundnut	- (9)	0 (1)	0 (40)
1995			
Cereals	5 (81)	0 (3)	20 (104)
Maize	5 (49)	- (0)	6 (9)
Cassava	178 (267)	2 (10)	13 (13)
Roots, other	150 (252)	- (4)	- (6)
Soybean	- (-)		
Groundnut	- (10)	- (1)	- (14)
2000			
Cereals	5 (102)	0 (5)	25 (135)
Maize	5 (70)	- (0)	6 (9)
Cassava	150 (225)	2 (91)	17 (17)
Roots, other	108 (23)	- (4)	- (6)
Soybean	- (-)	- (-)	
Groundnut	- (9)	- (0)	- (16)

Source: FAOSTAT

Figure ('000 metric tonnes) for wastes are in parenthesis

Table 21. Percentage utilization of crops for livestock feed and their wastages in selected countries of Central Africa (1991-2000)

Indices	Cameroon	Congo, D.R. of	Chad
1991			
Cereals	0.5 (7)	0 (50)	1.8 (11.6)
Maize	0.1 (8.5)	- (0)	6.3 (10.4)
Cassava	9.9 (15)	0.34 (2.2)	5.2 (5.2)
Roots, other	20.4 (24)	- (-)	- (13.3)
Soybean	- -	- -	- -
Groundnut	- (13.6)	0 (5.3)	- (25)
1995			
Cereals	0.4 (7)	0 (33.3)	2.3 (11.8)
Maize	0.81 (13.1)	0 (0)	9.5 (14.3)
Cassava	10 (15)	0.27 (1.4)	4.9 (4.9)
Roots, other	20 (33.6)	- (10)	- (15.8)
Soybean	- -	- -	- -
Groundnut	- (12.2)	- (5.3)	- (7)
2000			
Cereals	0.36 (7.3)	0 (71.4)	2.2 (11.9)
Maize	0.59 (8.2)	- (0)	7 (10)
Cassava	10 (15)	0.242 (10.9)	5 (5)
Roots, other	20 (4.3)	- (11.4)	- (15.8)
Soybean	- -	- -	- -
Groundnut	- (13.6)	- (0)	- (7)

Source: FAOSTAT
Percentages for wastes are in parenthesis

Table 22. Production ('000 metric tonnes) of cereals, roots, crops and oil seed in selected South African countries (1991-2000)

Crop Production	Zambia	Malawi	Zimbabwe	South Africa	Madagascar
1991					
Cereals	1 220	1 659	2 060	11 288	1 717
Maize	1 096	1 589	1 586	8 614	145
Cassava	682	168	100	1 323	2 307
Roots, others	-	0	-	-	115
Soybean	28	-	111	135	0
Groundnut	20	40	75	92	21
1995					
Cereals	878	1 761	987	7 490	1 826
Maize	738	1 661	840	4 866	177
Cassava	744	328	150	-	2 400
Roots, others	-	0	-	-	140
Soybean	21	-	77	59	0
Groundnut	25	22	37	82	21
2000					
Cereals	1 034	2 625	2 513	13 333	1 694
Maize	882	2 501	2 108	10 613	150
Cassava	815	900	175	-	2 228
Roots, others	-	0	-	-	190
Soybean	30	-	144	153	0
Groundnut	38	86	134	119	24

Source: FAOSTAT

Table 23. Crop import and export ('000 metric tonnes) in selected South African countries (1991-2000)

Crop Production	Zambia	Malawi	Zimbabwe	South Africa	Madagascar
1991					
Cereals	60 (1)	218 (3)	42 (558)	1 550 (601)	86 (16)
Maize	44 (1)	152 (1)	1 (528)	158 (493)	3 (15)
Cassava	0 (0)	0 (1)	0 (0)	24 (0)	0 (16)
Roots, others	-	0 (0)		0 (0)	- (0)
Soybean	- (1)	-	0 (1)	5 (0)	0 (0)
Groundnut	- (4)	0 (1)	0 (3)	31 (22)	0 (1)
1995					
Cereals	159 (2)	307 (9)	122 (471)	2 401 (1 883)	160 (7)
Maize	86 (2)	235 (3)	2 (312)	764 (1 619)	1 (7)
Cassava	0 (0)	0 (0)	0 (0)	13 (0)	0 (27)
Roots, others	0 (-)	0 (0)	0 (0)	50 (0)	- (0)
Soybean	1 (1)	0 (0)	6 (1)	173 (0)	0 (-)
Groundnut	0 (0)	0 (1)	1 (3)	51 (25)	0 (0)
2000					
Cereals	15 (1)	65 (6)	123 (192)	1 854 (970)	335 (3)
Maize	2 (0)	2 (0)	24 (107)	255 (726)	6 (3)
Cassava	0 (0)	0 (1)	0 (0)	11 (0)	0 (0)
Roots, others	0 (-)	0 (0)	0 (0)	47 (0)	- (0)
Soybean	2 (11)	0 (3)	13 (40)	94 (3)	0 (-)
Groundnut	0 (0)	0 (0)	2 (4)	10 (27)	0 (0)

Source: FAOSTAT
Export figures are in parenthesis

Table 24. Utilization of crops ('000 metric tonnes) for livestock seed and their wastage in selected South African countries (1991-2000)

Feed/wastes	Zambia	Malawi	Zimbabwe	South Africa	Madagascar
1991					
Cereals	62 (46)	81 (150)	154 (123)	3 705 (350)	187 (222)
Maize	60 (39)	80 (147)	150 (102)	3 200 (263)	7 (8)
Cassava	- (34)	- (20)	- (5)	- (-)	231 (206)
Roots, others	-	- (0)	-	0 (-)	34 (17)
Soybean	0 (1)	-	0 (2)	4 (4)	- (0)
Groundnut	0 (4)	- (3)	- (4)	- (4)	- (2)
1995					
Cereals	44 (56)	174 (184)	207 (124)	3 972 (385)	108 (240)
Maize	42 (43)	170 (178)	204 (102)	3 517 (297)	8 (10)
Cassava	- (37)	- (28)	- (8)	- (-)	240 (166)
Roots, others	- (-)	- (0)	- (-)	- (-)	42 (21)
Soybean	- (0)	- (-)	- (2)	4 (-)	- (-)
Groundnut	- (3)	- (2)	- (2)	- (3)	- (1)
2000					
Cereals	43 (56)	253 (193)	404 (129)	4 368 (415)	74 (237)
Maize	40 (47)	250 (187)	400 (108)	3 750 (326)	8 (10)
Cassava	- (41)	- (130)	- (9)	- (-)	223 (68)
Roots, others	- (-)	- (0)	- (-)	47 (-)	57 (34)
Soybean	- (1)	- (-)	- (3)	4 (7)	- (-)
Groundnut	- (4)	- (8)	- (7)	- (5)	- (1)

Source: FAOSTAT
Figures ('000 metric tonnes) for wastes are in parenthesis

Table 25. Percentage Utilization of Crops for Livestock Feed and their Wastages in selected South African countries (1991-2000)

Feed/wastes	Zambia	Malawi	Zimbabwe	South Africa	Madagascar
1991					
Cereals	5.1 (4)	49 (9)	7.5 (6)	33 (3.1)	11 (13)
Maize	5.5 (3.6)	5.0 (9.3)	15 (6.43)	37.1 (3.1)	5 (5.5)
Cassava	- (5)	- (12)	- (5)	- (-)	10 (8.9)
Roots, others	- -	- (0)	- -	0 (-)	29.6 (15)
Soybean	0 (4)	- -	0 (2)	3 (3)	- (0)
Groundnut	0 (20)	- (7.5)	- (5.33)	- (4.3)	- (4.8)
1995					
Cereals	5 (6.4)	9.9 (10.5)	21 (12.6)	53 (5.1)	6 (13)
Maize	5.4 (5.8)	10.2 (10.7)	24.3 (12.1)	72.3 (6.1)	4.5 (5.6)
Cassava	- (5)	- (8.5)	- (5.33)	- (-)	10 (7)
Roots, others	- (-)	- (0)	- (-)	- (-)	30 (15)
Soybean	- (0)	- (-)	- (2.6)	6.8 (11.9)	- (-)
Groundnut	- (12)	- (9.1)	- (5.4)	- (4)	- (4.8)
2000					
Cereals	4.2 (5.4)	9.6 (7.4)	16.1 (5.1)	33 (3.1)	4.4 (14)
Maize	4.5 (5.3)	10 (7.5)	19 (5.1)	35.3 (3.1)	5.3 (6.7)
Cassava	- (5)	- (20)	- (5.1)	- (-)	10 (3.1)
Roots, others	- (-)	- (0)	- (-)	- (-)	30 (17.7)
Soybean	- (3.3)	- (-)	- (2.1)	3 (4.6)	- (-)
Groundnut	- (0.5)	- (9.3)	- (5.2)	- (4.2)	- (4.2)

Source: FAOSTAT
Percentages for wastes are in parenthesis.

6. USE OF CASSAVA IN LIVESTOCK FEEDING IN WEST, EASTERN, CENTRAL AND SOUTHERN AFRICA

6.1 Historical perspectives, research and development activities

Historically and presently, cassava plays a minor role as an ingredient in livestock feeding in sub-Saharan Africa. This is largely due to cassava often being more expensive than imported maize for this purpose in Africa. The scenario of usage varies among different countries of sub-Saharan Africa.

In West Africa, Nigeria provides an interesting case of how government policies can influence the use of cassava as a livestock feed. In 1985 the Government of Nigeria banned the importation of maize and compelled livestock feed mills to look for local crop sources such as cassava. As a result the proportion of total cassava production used as livestock feed increased from 3-10 percent from 1985 to 1990. Though the ban on maize importation was lifted, cassava usage in the feed milling industries in Nigeria continued. However, due to a sharp rise in the price of cassava which follows its cycle of glut (excess cassava supply), the market price of cassava products is not competitive with maize for livestock feeding hence its utilization dropped to about 5 percent of total production in 2000 (Table 13). In Ghana cassava usage for feeds stands at 2 percent of total production while in Côte d'Ivoire it was 5 percent for 2000. In Liberia less than 1 percent of total production is used for intensive animal feeding (Ravindran and Ken Kpen, 1992).

In East Africa the usage of cassava is important for United Republic of Tanzania and Uganda. Cassava in livestock feed was 0.5 percent of total production in United Republic of Tanzania between 1991 and 2000. Lekule and Sarwatt (1992) indicate that it is only when grains are in very short supply that small quantities of cassava are included in feed in United Republic of Tanzania. In Uganda 25 percent of cassava was used for feed from 1991 to 1995 and increased to 27 percent in 2000 (Table 17). Cassava usage as feed in Ethiopia, Kenya and the Sudan is not significant.

Cameroon leads in usage of cassava for feed in Central Africa with percentage use increasing from 9.95 percent in 1991 to 10 percent in 1995 and 2000 (Table 21). The use in Chad was static at about 5 percent for the period 1991 to 2000 while in the D.R. of the Congo the quantity used for feed was minimal being static at about 0.25 percent for the same period.

The use of cassava for animal feed is important only in Madagascar in the South African region with about 10 percent of total production used in commercial feed milling (Table 25). In South Africa cassava is a recently introduced crop being presently used mainly in starch production. In Zambia the market price of cassava is higher than maize thus making it not competitive as a livestock feed (Mokuka, 2002 personal communication).

Resource and development activities on cassava in livestock feeding in sub-Saharan African date back to four and half decades when Oyenuga and Opeke (1957) demonstrated the satisfactory performance of intensively reared pigs on fresh and boiled cassava-based rations. Studies on pigs as well as poultry cattle, sheep and goats in different countries of sub-Saharan Africa are presented in Table 26.

6.2 Production utilization pattern of usage in traditional and commercial settings

The usage of cassava in traditional settings is largely by feeding of fresh or sun dried cassava roots and its by-products to livestock largely reared around homes in cassava processing sites. Peeled roots are normally fed to pigs while unpeeled roots are usually fed to cattle. The roots can also be sun dried after chopping and spread to dry on bare ground or on rock surfaces. Cassava leaves are also normally sun dried in the open or may be dried in ashes, but this takes longer, 10-15 days as in United Republic of Tanzania (Lekule and Sarwatt, 1991). Cassava leaves are also fed fresh to goats but varieties are selected to avoid poisoning. Also wilting of leaves is carried out but short-term wilting, three to four hours, usually results in toxic levels but 48 hours wilting is safe. Cassava peel in fresh or dried form also provides complimentary energy to cattle, sheep and goat in traditional systems.

Cassava and its by-products are of a highly variable quality and usually contain significant levels of contaminants like sand and microbial organisms like *Aspergillus flavus*. These can have more deleterious effects than the residual cyanide in cassava. Since cassava is usually fed as a supplement to livestock in traditional systems, the levels of inclusion vary depending on their availability as it is irregular. Being basically a human food in sub-Saharan Africa, only the wastes are predominantly fed in traditional systems.

Table 26. Cassava in feeding of different livestock species in sub-Saharan Africa

Livestock Species	Role and level of cassava in diet		Response	Reference	Country
Swine: A) Growing/ finishing pigs	i)	Raw or boiled cassava as total replacement to maize	Satisfactory growth at total replacement of maize	Oyenuga and Opeke (1957)	Nigeria
	(ii)	0-40% sun-dried cassava flour inclusion	Satisfactory growth at 28% level	Tewe (1982)	Nigeria
	(iii)	0-60% cassava root meal inclusion	Satisfactory growth of 40% level	Lekule and Sariwatt (1992)	Tanzania
	(iv)	0-40% cassava peel meal	Satisfactory growth at 10% level	Tewe and Oke (1983)	Nigeria
	(v)	0-40% cassava flour in ration	Satisfactory growth at 40%	Ravindran and Kenkpen (1992)	Liberia
	(vi)	Cassava root meal concentrate as meal or pellets	Satisfactory growth on pelleted feeds	Tewe and Bokanga (2001)	Nigeria
B) Gestating pigs		Total replacement of maize with fresh cassava storage roots	Satisfactory litter size and lactation	Tewe (1975)	Nigeria
Poultry a) Chicks		0-10% of root meal inclusion in ration	Satisfactory growth at 10% level	Job *et al.* (1980)	Nigeria
b) Growers		0-25% of root meal inclusion in ration	Satisfactory growth at 5% level	Job *et al.* (1980)	Nigeria

Table 26. Cassava in feeding of different livestock species in sub-Saharan Africa (cont.)

Livestock Species	Role and level of cassava in diet		Response	Reference	Country
c) Broilers		0-30% of root meal inclusion in ration	Satisfactory growth at 10% level	Tiemoko (1992)	Côte d'-Ivoire
		0-51% inclusion of root meal in ration	Satisfactory growth at growth at 34% level	Kinabo (1977)	Tanzania
d) Layers		Total replacement of maize flour or pelleted with cassava root meal	Satisfactory growth and egg production	Tewe and Bokanga (2001)	Nigeria
<u>Ruminants</u>					
a) Dairy	(i)	Total replacement of maize with cassava flour in concentrate	Increased milk and fat yield	Olaloku, Egbunike and Oyenuga (1971)	Nigeria
	(ii)	Total replacement of maize with cassava root meal	Satisfactory milk yield and fat levels	Sanda and Methu (1992)	Kenya
b) Sheep		Cassava peel as supplement to grass	Satisfactory improvement in weight gain	Fomunyan and Meffeja (1987)	Nigeria
c) Goat	(i)	Fresh cassava as supplement to grass legume forages	Satisfactory growth and nutrient digestibility	Smith (1992)	Nigeria
	(ii)	Cassava flour as supplement to citrus pulp	Satisfactory growth	Akinsoyinu and Mba (1978)	Nigeria

Cassava also plays an important role in pastoralist cattle feeding. In Nigeria during the dry season, free ranging cattle are moved southwards in search of pasture. At the peak of the dry season it is usually cassava farms alone that retain their 'greenness'. It is usual for cattle to ravage such farms consuming the foliage and trampling on the roots. Communal clashes resulting from this occurrence are attaining prominence when cattle rearers are not settled. The potentials for utilizing wastes of cassava which varies in different countries of sub-Saharan Africa can be up to 52 percent of total production as in Nigeria (Table 13), 10 percent in Uganda (Table 17), 15 percent in Cameroon (Table 21) and

20 percent in Malawi (Table 27); the respective tables show the vast potential of this root crop in traditional systems.

Cassava usage in commercial settings is usually in the form of dried root chips which are milled into flour before incorporation into compound feeds usually for commercial poultry. Processing cassava into chips involves harvesting of the roots and peeling. This is usually unaccompanied by washing. They are usually chopped with cutlass into bits or left as whole peeled storage roots and sun-dried on bare ground or where available, on rocks. The quality of such chips varies greatly being highly contaminated with sands and microbes when dried on bare ground and in humid areas where cassava cultivation is prominent. In the drier and rocky areas the chips are cleaner, whiter, drier and less contaminated. Recently, simple machines have been developed for chipping cassava roots before drying. This consists of a driven disc with radial chipping slots fitted with cutting blades. These chips are sold to commercial feed millers who mill this into powder. This process releases a lot of dust from the cassava during milling and an appreciable quantity is thereby lost. Levels of inclusion of cassava in poultry feeds is between 5-10 percent in Nigerian feed mills and such mixes include full fat Soya to ensure reduction of dust in such compound feeds. As an alternative, palm oil is added on farms that mix their own feed to reduce dustiness.

A cheaper and cost effective method for processing cassava into chips and pellets has been developed at the International Institute for Tropical Agriculture (Tewe and Bokanga, 2001). This involves harvesting the cassava roots, washing and chipping with a motor or manual driven chipper before sun-drying on cemented floor with turning twice daily using a rake. This procedure eliminates the peeling cost. This product is competitive with maize in the livestock feed industry as it is marketed at about 60 percent of the price of maize. The cassava chip can also be mixed with shredded and similarly dried cassava leaves mixed in a 4:1 ration cassava root meal: leaves milled and pelletized using a manual or motor driven pelletizer. The pelletizing process has been simplified by eliminating the need for drying before pelletizing. In this most recent technique the washed unpeeled cassava root is grated, dewatered and passed straight into the pelletizer where it is steamed and the resulting hot pellets are sun-dried or oven dried. The product is not only cost effective to the feed miller as compared with maize, but a cottage industry can be profitably sustained on this product which can be established at the farm gate rural level.

It should be noted that African cassava chips and pellets are not competitive in European livestock feed markets because of the high cost of production and transportation in Africa and from Africa. The recent experience of cassava chip production and export in Ghana is an example. Africa has been an unreliable supplier of pellets (Phillips, 1973).

According to Nweke *et al.* (2002), the production of cassava in Africa is notoriously unstable because of weather induced fluctuations in food production. Africa's unstable supply of cassava discourages European buyers who have a long history of relying on more stable Asian and Latin American suppliers. Africa cassava products are also low in quality because of the inefficient traditional processing methods.

6.3 Use of cassava as animal feed to enhance food security

In collaboration with national programmes, the International Institute for Tropical Agriculture (IITA) has developed high yields and stable cassava lines and many national cassava improvement programmes in sub-Saharan Africa have released improved cassava varieties resulting from IITA's work. Higher productivity is therefore being recorded in many African countries with Nigeria becoming the worlds leading cassava producer. The increase in cassava production needs to be matched with diversification of usage of this root crop beyond its traditional role of being a staple food on the continent. The cycle of glut, which follows excessive production of cassava in Nigeria and other countries in Africa, is a result of lack of alternative markets for this root crop. Cassava trade needs to be boosted to ensure that farmers can earn adequate income from it to empower them economically, sustain the production system and enhance food security on the continent. The development of new and alternative uses and products from cassava is therefore critical to its transformation from a staple food to becoming a livestock feed component and industrial raw material.

Alternative uses for cassava exist in its transformation into novel foods, livestock feeds, starches, ethanol and pharmaceutical products. Among these alternatives, livestock feeds appear to be the most promising because of the following reasons:

- the standards required for feed grade cassava products are not as stringent as for other products. The possibilities of packaging technologies affordable and practicable at the farm gate level for livestock feed cassava products are highly promising;
- with animal protein consumption projected to increase on the continent, there is tremendous potential for growth of the animal feed industry which is the main component of costs in livestock production. The possibilities of cassava playing a vital role in the supply of feed ingredient to the industry is also not doubted;
- availability of maize which is the main energy source in compound livestock feeds is being threatened as many African nations cannot afford importation of maize due to huge foreign debts and currency devaluation. Local production of maize is also hampered by escalating costs of fertilizer and unfavourable weather conditions in many African countries. The need for cassava as an alternative energy source becomes imperative in order to ensure adequate energy supply in livestock compound and supplemental rations.

With improved productivity, surplus cassava is anticipated in many African countries and this can lower farm prices for cassava products. As cassava is essentially an energy source, it is necessary for cassava farmers to earn income to enable them to purchase other feeds like cereals and pulses among others to ensure balanced nutrient in-take and maintain a healthy household. Failure to expand the cassava market at the rural level to livestock feed products will hamper the socio-economic status of cassava farming populace and therefore erode their food security. Thus, transformation of cassava into livestock feed ingredients therefore becomes imperative to prevent malnutrition and poverty among rural households which constitute over 90 percent of cassava producers on the continent.

7. STRATEGIC INTERVENTIONS FOR CASSAVA IN LIVESTOCK PRODUCTION IN WESTERN, EASTERN, CENTRAL AND SOUTHERN AFRICA

7.1 Identification of gaps, opportunities and constraints

African countries are at different stages of transformation of cassava from a famine reserve crop through staple food, cash crop and lastly industrial raw material and usage for livestock feeding. According to Nweke *et al.* (2002), COSCA studies in six African countries show that Nigeria, the leading world producer of cassava is the most advanced and is now poised to move to the stage of using cassava for livestock feed and industrial raw material. For this transformation to occur it is necessary to identify markets to absorb the increase in cassava production. The wide spread adoption of TMS varieties and the resulting increase in yields have shifted the problem of the Nigerian cassava industry from supply (production) to demand issues such as finding new uses for cassava in livestock food and other industries. Indeed while Nigeria has moved its cassava industry from a rural staple food to the urban and food export stage, a cycle of glut (excess cassava) has occurred every four years in the industry in the last decade. It was noted by the director of the Federal Department of Agriculture in Nigeria in early 2001 that cassava producers were losing money because of a glut in the market and declining cassava prices (Nweke *et al.,* 2002). Therefore, there is a need for further diversification of cassava usage.

In Nigeria the proportion of cassava used in the livestock industry increased after the Government banned the importation of maize in 1985-86 and feed mills were forced to use cassava. Cassava was attractive because it was cheaper than maize. While the expertise to utilize this root crop is established in the feed milling industries, the price of cassava has escalated in recent times due to its scarcity following the period of glut; hence the quantity in use for feed has declined considerably to 5 percent of total production in recent times. Cost is therefore a major factor to take into consideration in substituting cassava for maize in livestock rations. In studies from various countries, the reported levels of the price of cassava as a proportion of the price of maize to make cassava competitive obtained from Côte d'Ivoire, Nigeria, Thailand and Zimbabwe indicates a range between 60 and 75 percent of the price of maize. Low cost processing technologies therefore need to be adopted. In recent studies in Nigeria by Tewe and Bokanga (2001), whole unpeeled cassava roots and leaves were washed, shredded, sun-dried and milled prior to their being pelletized in a ratio of four parts of cassava root meal to one part of cassava leaf meal. The high cost of peeling of cassava roots which is a major constraint in cassava processing is thus eliminated. It should be noted that even unpeeled roots are processed and exported from Thailand into the European Union. On the other hand, almost all the cassava flour adopted by feed millers in Nigeria is from the peeled storage roots.

Ghana is also at the third stage of the cassava transformation process as classified by Nweke *et al.* (2002). Indeed, it had embarked on an export of cassava chips and pellets to the European Union within the last decade. This project is threatened by the high cost of production, transportation, irregularity and quantity of products. Unless the cost of cassava production drops considerably to about US$20 as obtained in South Africa, the competitiveness of cassava in the export market will not be realized.

In Côte d'Ivoire, Tiemoko (1992) noted that the recommended price of 75 percent cassava cost relative to maize is rarely met as the price paid for cassava is generally high and often higher than the price of maize. Under such conditions, it seems that the opportunity cost of cassava for human consumption exceeds its value for human food. With the introduction of improved TMS varieties in Côte d'Ivoire the higher productivity and surplus production will justify its inclusion in commercial livestock rations. Similarly reports from Liberia (Ravindran and Kenkpen, 1992) confirm that almost all the cassava harvested is processed into various forms for human consumption. Large-scale utilization of cassava as animal feeds is only practiced at the government agricultural research station (CARI). Higher production of cassava may lead to its increased utilization as animal feed. In this regard, CARI has already released onto the market some animal feed formulations based on cassava roots as the major energy source.

In East Africa, United Republic of Tanzania and Uganda indicate that presently the proportion of cassava used for livestock feed constitutes 0.3 and 27 percent of total production, respectively (FAOSTAT). Similarly export of cassava from United Republic of Tanzania stood at 164 000 metric tonnes in 1991 and declined to 15 000 metric tonnes in the year 2000. Lekule and Sarwatt (1992) reported that in United Republic of Tanzania, in areas where cassava is a staple food, there is always an excess of production which is sold to the National milling corporation, most of which is exported. Presently, it is only when grains are in very short supply that some amounts of cassava chips are included in feeds. Another problem is that cassava is produced in dry areas where intensive livestock production is not practiced. Also, the high price of cassava makes its use in livestock feeds uneconomical. The need for improved cost-effective processing techniques to produce cheap cassava chips and pellets for the local and export markets is a major constraint in United Republic of Tanzania. With 556 000 tonnes or 27 percent usage of cassava for animal feed in Uganda (FAOSTAT), the country stands as having the highest percentage usage as animal feed not only in the region but in the whole of sub-Saharan Africa. As reported by Otim-Nape, donor interest in the introduction of the TMS variety in Uganda was sparked by the appearance and rapid spread of cassava mosaic in the late 1980s. By the year 2000, 80 000 ha of the mosaic resistant TMS varieties were under cultivation. The higher productivity of cassava and its competitive price to maize explains the high percentage usage of this root crop for livestock feeding in Uganda.

Ethiopia, Kenya and the Sudan have no recorded usage of cassava for livestock feeding. The higher livestock density to human population in these countries as compared with United Republic of Tanzania and Uganda (Table 11) shows tremendous potentials for use of cassava for livestock feeding if the improved TMS varieties are promoted in these countries. Sanda and Methu (1992) reported that in the high cassava producing areas of western and coastal regions of Kenya, excess cassava is not always fermented before being sun-dried. These regions also have notable household dairy units; one or two exotic breeds being used for milk production. Supplement feeding with sweet potato roots and leaves in this region increases the profit margin of milk producers from almost 90 to 1 000 Kenyan shillings per week. Complete substitution of maize meal with cassava meal in the dairy ration in western Kenya has also been demonstrated to be economical and associated with a reduction in feed cost of Kenyan shillings 328 (US$10 per tonne). Cassava roots and leaves therefore have high potential for usage in this region and by extension in other cattle producing areas of sub-Saharan Africa where cassava can be profitably cultivated.

In Central Africa, Cameroon shows great potential as its utilization of cassava for livestock feed has been maintained at about 10 percent of production between 1991 and 2000. Also, use of other roots steadied at about 20 percent of production within the same period. The competitive price of cassava and other root crops, notably sweet potato, to that of maize in Cameroon might explain higher percentage utilization than for maize, which stands at 5 000 metric tonnes as compared with 150 000 metric tonnes for cassava in 2000 (Tables 20 and 21).

In Chad, percentage cassava usage is also significant at 5 percent of production or 17 000 metric tonnes. With the high cattle and poultry population in Chad and Cameroon, high potentials exist for exploiting cassava usage for feed. Also export of dry chips holds high promise in Chad and other arid and semi-arid regions of Africa due to intense solar energy which still remains the main source of drying cassava for local use or export. The D.R. of the Congo reveals very low usage of cassava for livestock as most of its cassava is for traditional foods. Also the poor road infrastructure in the country increases transportation costs making it unfeasible to produce cassava products competitively to maize.

Madagascar in the South African region indicated a steady usage of cassava in livestock feeding at 10 percent of total production between 1991 and 2000. It is noteworthy that while use of maize declined from 187 000 metric tonnes in 1991 to 74 000 tonnes in 2000, cassava usage remained constant at 223 000 metric tonnes in 2000, representing about three times the quantity of maize used for this sector. Within the region, it also has the highest cattle density caput. Its pig population declined considerably due to the African Swine Fever Epidemic. Its pig industry was a major consumer of the cassava-based feeds. The opportunities lie in diversifying cassava usage to other livestock species.

South Africa’s interest in cassava cultivation is very recent. It is however, presently the model in cassava plantation in Africa with a single plantation of 5 000 ha with a yield of 50 tonnes/ha. The cost of production is also estimated at about US$20 per tonne. With modern planting techniques and inputs, this industry envisages expansion to 10 000 ha plantation in the very near future (Cassey, 2000 personal communication). Its emphasis is on the production of starch for the region and export market. With the lowest cost of cassava production per tonne in Africa, this root crop stands a high chance of competing with maize as an energy source in its livestock industry. Moreover, the waste from the starch industry which includes the peels, leaves and starch sieviate constitute pollutants which can be profitably harnessed particularly for ruminant feeding. With 119 000 000 poultry, use of cassava in the poultry industry will appear economically feasible, if appropriate processing technologies are put into place.

Zambia has enormous potentials of cassava usage in its livestock industry; however, the feed industry is very reluctant to take on this opportunity because of the high cost of cassava chips which is put at about US$300/tonne as compared with maize at US$220/tonne. The price of cassava however, drops to US$150/tonne during the dry season (Mokuka, 2002 personal communication). The opportunity to use cassava in the dry season feeding of livestock is apparent. Presently, cassava is not used in commercial feed milling although leaves and peelings are used in the traditional system of rearing. The government agricultural research station is presently promoting the use of cassava in commercial milling as unfavourable weather patterns have led to a serious decline in maize production in recent times

7.2 Practical cassava-based feed formulations

A major limitation to adoption of cassava-based feeds in sub-Saharan Africa is the absence of necessary information on cost-effective formulations for different livestock species. Such rations need to be packaged for different livestock production systems in different agro-ecologies of the continent. Information provided in this regard will build the confidence of livestock farmers and feed producers to substitute cassava for maize in commercial rations where the price favourably dictates a competitive advantage for cassava. This is envisaged to happen in many countries of Africa with the rapid spread of disease resistant high yielding TMS varieties when this is combined with modern production techniques with resultant yield increase and reduced cost of production per metric tonne. Tables 27-36 provide linear programmed cost effective formulations in rations for poultry (chick starter, growers, layers and broilers) growing pigs, beef cattle, sheep, goats, dairy cattle, rabbits and cat fish. These computerized formulations include partial or total substitution of maize with cassava root meal. Peels and leaves are included in some formulations. Prices are based on the Nigerian market prices of ingredients except the cassava products which are novel feed ingredients developed at the IITA (Tewe and Bokanga, 2001) with costs of the cassava products being about 40 percent lower than that of maize. While the formulations are not exhaustive, they provide a useful baseline for cassava feeds and can be manipulated to fit specific production systems and different agro-ecologies in sub-Saharan Africa.

Table 27. Maize and cassava-based feed formulations for poultry (chick starters) (by least cost linear programming)

Ingredients	Maize	Cassava-Level 1	Cassava-Level 2
Maize	40.5	33	-
Cassava flour	-	10	45
Cassava leaves	-	-	10.3
Soybean meal	20	-	-
Toasted soya	-	20	27
Groundnut cake	6	10	-
Maize offal	17	11	7
Wheat offal	6.8	6.3	-
Fish meal	4	4	5
Oyster shells	2	2	2
Bone meal	3	3	3
Salt	0.25	0.25	0.25
Premix	0.25	0.25	0.25
Methionine	0.1	0.1	0.1
Lysine	0.1	0.1	0.1
Cost (Naira/tonne)	34 908.5	34 493.5	31 457.5
Cost reduction (%)		1.2	9.9

US$1= 128 (Naira)

Table 28. Maize and cassava-based feed formulations for poultry (growers) (by least cost linear programming)

Ingredients	Maize	Cassava Level 1	Cassava Level 2
Maize	24	13	-
Cassava flour	-	15	30
Cassava leaves	-	-	8
Soybean meal	2	3	7.5
Groundnut cake	4.5	7.5	-
Maize offal	29	21.5	18
Palm kernel cake	19	19	18.5
Wheat offal	16.5	16.5	15
Fish meal (65%)	1	1	1
Oyster shells	1.5	1.5	1.5
Bone meal	2	2	2
Salt	0.25	0.25	0.25
Premix	0.25	0.25	0.25
Cost (Naira/tonne)	21 890	21 140	19 172.5
Cost reduction (%)		3.4	9.9

US$1= 128 (Naira)

Table 29. Maize and cassava-based feed formulations for poultry (broilers) (by least cost linear programming)

Ingredients	Maize	Cassava Level 1	Cassava Level 2
Maize	50	27	-
Cassava flour	-	23	45
Cassava leaves	-	-	5
Palm oil	-	3	3
Soybean (full fat)	-	-	20
Soybean meal	12	20	-
Groundnut cake	20	12	15.25
Wheat offal	6.3	3.25	-
Fish meal (65%)	6	6	6
Oyster shells	2	2	2
Salt	0.25	0.3	0.3
Premix	0.25	0.25	0.3
Methionine	0.1	0.1	0.1
Lysine	0.1	0.1	0.1
Cost (Naira/tonne)	37 453.5	37 279	33 344
Cost reduction (%)		0.5	11

US$1= 128 (Naira)

Table 30. Maize and cassava-based feed formulations for poultry (layers) (by least cost linear programming)

Ingredients	Maize	Cassava Level 1	Cassava Level 2
Maize	40	34	-
Cassava flour	-	10	40
Cassava leaves	-	-	11
Maize bran	15.5	7	10
Soybean (full fat)	-	-	10
Soybean meal	5	6	5
Groundnut cake	9.5	10	-
Wheat offal	10	10	6
Palm kernel cake	8	11	6
Fish meal (65%)	2	2	2
Oyster shells	7.5	7.5	7.3
Bone meal	2	2	2
Salt	0.25	0.25	0.25
Premix	0.25	0.25	0.25
Methionine	0.1	0.1	0.1
Lysine	0.1	0.1	0.1
Cost (Naira/tonne)	27 310	26 287.5	23 497.5
Cost reduction (%)		3.7	14

US$1= 128 (Naira)

Table 31. Maize and cassava-based feed formulations for pig feed supplements (by least cost linear programming)

Ingredients	Maize	Cassava Level 1	Cassava Level 2	Cassava Level 3
Maize	30	-	-	20
Maize bran	-	-	-	10
Cassava flour	-	35	-	20
Cassava peels	-	-	40	10
Cassava leaves	-	-	-	-
Palm kernel cake	43	38	13	13
Palm oil	-	-	10	-
Wheat offal	-	-	24	14
Wheat bran	14	14	-	-
Blood meal	5	5	5	5
Soybean (full fat)	5	5	5	5
Bone meal	2	2	2	2
Salt	0.5	0.5	0.5	0.5
Premix	0.5	0.5	0.5	0.5
Cost (Naira/tonne)	19 795	18 895	18 395	16 765
Cost reduction (%)		4.5	7	15.3

US$1= 128 (Naira)

Table 32. Maize and cassava-based feed formulations for beef cattle feed supplements (by least cost linear programming)

Ingredients	Maize	Cassava Level 1	Cassava Level 2
Maize	25	-	-
Cassava flour	-	30	-
Cassava leaves	-	10	20
Cassava peels	-	18	21.5
Palm kernel cake	25	20	30
Groundnut cake	5	5	-
Brewers' dried grains	18	-	-
Poultry droppings	13.5	13.5	25
Wheat offal	10	-	-
Bone meal	2	2	2
Premix	0.5	0.5	0.5
Salt	1	1	1
Cost (Naira/tonne)	16 715	13 200	7 850
Cost reduction (%)		21	53

US$1= 128 (Naira)

Table 33. Maize and cassava-based feed formulations for sheep and goat feed supplements (by least cost linear programming)

Ingredients	Maize	Cassava Level 1	Cassava Level 2
Maize	20	-	-
Cassava flour	-	20	-
Cassava leaves	-	8	5
Cassava peels	-	-	15
Wheat offal	8	-	-
Maize offal	-	-	20
Palm kernel cake	30	30	30
Groundnut cake	5	5	3
Brewers' dried grains	20	20	-
Poultry droppings	15	15	25
Bone meal	1	1	1
Salt	1	1	1
Cost (Naira/tonne)	13 155	11 195	9 605
Cost reduction (%)		14.9	27

US$1= 128 (Naira)

Table 34. Maize and cassava-based feed formulations for dairy cattle feed supplements (by least cost linear programming)

Ingredients	Maize	Cassava Level 1	Cassava Level 2	Cassava Level 3
Maize	57	34.5	9.5	-
Cassava flour	-	20	45	57
Cotton seed cake	28	28	28	28
Palm kernel cake	15	8.5	8	4.5
Wheat offal	5	5	5	5
Urea	-	0.5	1	2
Premix	2.5	3	3	3
Salt	0.5	0.5	0.5	0.5
Cost (Naira/tonne)	34 935	32 335	28 935	27 435
Cost reduction (%)		7.4	17.2	21.5

US$1= 128 (Naira)

Table 35. Maize and cassava-based feed formulations for rabbit feed supplements (by least cost linear programming)

Ingredients	Maize	Cassava Level 1	Cassava Level 2
Maize	38	-	-
Cassava flour	-	38	35
Cassava leaves	-	-	14
Maize bran	10	10	15
Groundnut cake	11	13	-
Palm kernel cake	20	18	15
Brewers’ dried grains	12.5	12.5	15.5
Fish meal	5	5	2.5
Bone meal	3	3	3
Premix	0.5	0.5	0.5
Cost (Naira/tonne)	27 645	22 705	19 860
Cost reduction (%)		17.9	28.2

US$1= 128 (Naira)

Table 36. Maize and cassava-based feed formulations for fish (catfish) feed supplements (by least cost linear programme)

Ingredients	Maize	Cassava pellets
Maize	15	-
Cassava flour	-	12
Cassava leaves	-	3
Palm oil	1.5	2
Groundnut cake	15	14.5
Soybean meal	20	20
Fish meal (65%)	20	20
Blood meal	25	25
Oyster Shells	1	1
Bone Meal	1	1
Salt	0.5	0.5
Dicalcium phosphate	0.4	0.4
Vitamin C	0.1	0.1
Premix	0.5	0.5
Cost (Naira/tonne)	46 996	44 780
Cost reduction (%)		4.7

US$1= 128 (Naira)

Table 37. Composition and cost of maize or cassava-based tested layer diets

Ingredients	Maize-based diet	Cassava mash-based diet	Cassava pellet-based diet
Maize	45	-	-
Cassava root-leaf mixture	-	47	47
Palm oil	-	3	3
Other additives	55	50	50
Calculated energy (Kcal/kg Me)	2 519	2 513	2 513
Calculated crude protein (%)	16.7	16.8	16.8
Feed cost/tonne (US$/tonne)	269	233	243
Feed cost reduction (%)		13.4	9.7

Source: Tewe and Bokanga, 2002

8. FEASIBILITY OF USING CASSAVA VERSUS MAIZE OR WHEAT

8.1 Cassava as partial or total substitute for other energy sources

Energy sources constitute between 15 and 60 percent of compound livestock feeds and concentrates. Presently, maize constitutes the bulk of the energy source in such rations. Other grains, which are used to a lesser extent, include sorghum, millet, wheat, barley and oats. The difficulty in obtaining foreign exchange in many African countries has considerably reduced the imports of maize and other cereals. At the same time local production of cereal grains remain grossly inadequate for food and feed industries. Their shortages have therefore resulted in astronomical increases in the price of grains in the last decade. Cassava production has been rising steadily in many African countries and its availability has only to be matched with competitive pricing to make its use in livestock feeds feasible. Where it is a cheap carbohydrate source it is capable of supplying adequate calories and therefore offers great potential as animal feed. However, due to certain limitations such as its low content of protein, vitamins and some minerals and lack of sulphur, containing amino acid such as methionine, it is often rated as inferior to maize or wheat. Research on cassava as an animal feed which commenced in 1903 with the study of Tracy on pigs in the USA, has over the last century shown the importance of cassava in animal nutrition and its suitability as an energy source in compound rations when properly balanced in proteins, vitamins and minerals. Presently its competitive pricing with maize is the major limitation to its large-scale use in commercial feed milling. Prices of cassava should range between 60 and 70 percent of that of maize to be economically feasible as reported in different countries (Table 43). Other factors that need to be considered in formulating balanced cassava rations include:

- oil supplementation or pelletizing in order to reduce its dustiness and the latter to improve the starch utilization in cassava feeds. Also addition of fats, molasses or pelletizing have been found to improve palatability of cassava diets which is due to its powdery nature;
- adequate supplementation of monogastric rations with sulphur amino acids to detoxify residual hydrocyanic acid and supply enough for productive purposes;
- there is a need to synchronize the release of proteins in forage with energy from cassava in ruminant rations in order to obtain favourable productive responses;
- the advantage of non-protein nitrogen in the form of urea nitrogen or poultry droppings to provide cheap protein in cassava rations for ruminants will reduce supplementation costs.

There has recently been a significant drive to improve the energy availability of cereals and cereal by-products particularly from maize and wheat. This is through supplementation of such cereal-based rations with polysaccharidase enzymes specific to break the non-starch polysaccharidic bonds in complex and unavailable fibrous components in such cereals and by-products. The feasibility of these is still under test in some countries of sub-Saharan Africa. The relative advantage of such supplementation still remains very doubtful. Cassava as a cheap energy source can play a vital role in energy supplementation as a partial substitute for maize or wheat in such cereals or by-product-based rations. Its readily available carbohydrate as an energy source can therefore be tapped to complement such efforts being directed to cereals and cereal by-products.

8.2 Satisfactory levels of cassava in relative feed rations for poultry, pigs and ruminants

The practicability of life cycle feeding of cassava to different livestock species has been demonstrated if the cassava-based diets are adequately supplemented with proteins, minerals and vitamins.

- **Poultry**: poultry feed constitutes the largest proportion of the commercial ration produced by feed millers for intensive livestock production. The use of cassava as a substitute for maize or wheat will therefore have its greatest impact if it can be incorporated into commercial poultry feeds. Satisfactory growth response has been obtained for growing chicks on inclusion of between 5-10 percent cassava flour in chick ration in most of the reported trials (Table 26). A recent study in Nigeria by Tewe and Bokanga (2001) revealed the importance of the form of feeding cassava on the performance of birds. A cassava root-leaf mixture in a ratio of 4:1 was used to replace maize and offered in the dried marsh or pelletized forms. The cassava level was 47 percent of rations as shown in Table 37. The performance revealed satisfactory egg production and body weight gain with complete substitution of maize with cassava. Egg yolk colour was also markedly improved on the pelletized ration due to the higher carotenoid content imparted by the cassava leaves which was mixed into the cassava pellet or marsh. There was a consistent cost-saving of the cassava plant-based rations as compared with the maize-based rations.

In the European Union a 20 percent inclusion of cassava in poultry rations is recommended for satisfactory poultry production (Wood, 1992). Pelletizing is also recommended as dustiness of cassava feedstuff can reduce feed intake in poultry, which adversely affects productivity. Tolerable levels of hydrocyanic acid in cassava chips and pellets imported into the EU have been fixed at a maximum of 100 mg/kg as shown in Table 39. The cassava quality requirements for cassava products imported into the European Community countries are shown in Table 38.

- **Pigs**: the suitability of cassava root meal as a total replacement for maize in growing/finishing and gestating pigs has been demonstrated in many studies as shown in Table 26. Precautions to be taken to guarantee satisfactory performance include removal of cyanide through boiling, grating, soaking, fermenting and drying or a combination of these processes to produce final products containing no more than 100 mg/kg hydrocyanic acid and the prevention of microbial activity during sun-drying, particularly in a humid environment.

Another feeding trial in Nigeria by Tewe and Bokanga (2001) involved feeding of growing pigs with maize or cassava-based feed supplements. The cassava mix which also contained whole (unpeeled) cassava root and leaf meal in a ratio of 4:1 was presented in various forms. As shown in Table 39, the cassava mix supplement was presented in the threshed, milled or pelletized forms. The feeds were compared with a cereal-based supplement and also a diet which consisted of palm kernel cake solely fed to growing pigs. The performance showed that feed intake, body weight gain and feed conversion were highest on the pelletized cassava plant-based supplement. Indeed the period to attain market weight of 100 kg body weight was 195 days (6.5 months) on the pelletized cassava supplement as compared with 234 days (7 months, 24 days) on the cereal-based supplement and 366 days (12 months) on the sole palm kernel cake ration. Earlier studies in Nigeria (Tewe and Oke, 1983) with growing pigs showed satisfactory performance on diets containing 40 percent dried cassava peel and discarded small storage roots. With cassava peels alone performance was best at 10 percent inclusion. Leaner carcasses and cost reduction of feed were obtained in the cassava diet compared with maize.

In the European Union cassava chips are incorporated in growing swine rations at up to 40 percent of ration with satisfactory performance (Table 40). The inclusion level of cassava root meal or pellets in livestock feeds used in two European Community countries is presented in Table 41. Apart from dried cassava, pigs can also be fed with fresh, boiled or ensiled cassava roots as is commonly practiced in small- and medium-scale pig farming enterprises in many African countries.

- **Ruminants**: ruminant responses to cassava-based rations demonstrate that when cassava foliage was used as a supplement to *Pennisetum purpureum*, performance of fattening steers in terms of weight gain, feed intake and feed efficiency were markedly improved (Moore, 1976). An acceptable level of substitution of the basal grass ration was 50 percent cassava foliage. It is a common occurrence to see cattle grazing on foliage in cassava farms in Nigeria, particularly in the dry season when foliage is very scarce;
- dried cassava peel fed as a supplement to *Pennisetum purpureum* basal ration for sheep, revealed satisfactory weight gain, feed intake and dry matter digestibility with 30 or 70 percent substitution with dried cassava peels (Fomuyan and Meffeja, 1987).

Fresh cassava roots fed as a supplement to *gliricidia* and *leuceania* for goats, improved growth rate only when the feeding of the cassava roots was synchronized in such a manner that its feeding time was close to that when:

- the basal diet of browse or grass is fed. Thus, cassava should be split fed three times daily to ensure its synchronization with forage (Smith, 1992).

Dairy cattle's rearing in small homestead farms is a common feature in western Kenya. A study in Kenya by Sanda and Methu (1992) revealed that complete replacement of maize with cassava flour and nitrogen supplementation of the cassava diets with urea gave similar milk yield and butter fats on cassava or maize-based concentrates. Cost reduction of US$10/tonne on the cassava diets was also reported. Cassava roots and leaves therefore have high potentials in smallholder and commercial dairy farms in different parts of sub-Saharan Africa.

Table 38. Current quality requirements for cassava products imported into European Community countries.

Feedstuff	Description	Composition	Requirement
Manioc meal	Dried and if necessary washed and peeled	Starch Moisture	75% or more 13% or less
Chips or roots	Manioc roots; also products obtained by crushing and grinding	Crude fibre Crude ash Ash insoluble in HCl	5.2% or less 5.5% or less 3.3% or less
Manioc types meal	Unpeeled manioc roots and washed, if necessary	Starch Moisture Crude fibre	63% or more 13% or less 9% or less
Flakes roots	Products obtained by crushing and grinding	Crude ash Ash insoluble in HCl	6% or less 4% or less

General requirements for straight feedstuffs (12 percent moisture basis):

Aflatoxin: 0.05 mg kg^{-1} or less

Cyanogens: 100 mg HCN equivalent kg^{-1} or less

Source: Wood, 1992

Table 39. Composition of maize and cassava-based feed supplements for pigs (cassava mix presented in various forms)

Ingredients	Maize-based supp.	Threshed cassava mix supp.	Milled cassava mix supp.	Pelletized cassava mix supp.	Farmers' diet (PKC)
Wheat offal	40	-	-	-	-
Palm kernel cake	39.25	-	-	-	100
Cassava root-leaf mix	-	79.25	79.25	79.25	-
Other additives	20.75	20.75	20.75	20.75	-

Source: Tewe and Bokanga, 2001

Table 40. Typical raw material inclusion levels in livestock feed (%) used in two European Community countries.

	Pig finisher		Layer		Broiler	
	Holland	U.K.	Holland	U.K.	Holland	U.K.
Cereals	-	54	7	60	22	69
Cereal by-products	18	9	15	7	-	1
Vegetable protein	28	24	35	17	39.5	14
Animal protein	8.5	7	7	7	8.5	11
Cassava	37	-	24.5	-	20.5	-
Oil and fat	2.5	2	3	1	7.5	4
Others	6	4	8.5	10	2	1

Source: Wood, 1992

8.3 Price relationship between cassava, maize, other cereal substitutes, soybean meal and other protein supplements

Cassava competitiveness with maize in some African countries has been largely dictated by its form of presentation as a dry cereal (garri) and the advantageous price differential between this product and the conventional cereal-based foods. Indeed, these factors have promoted the transformation of cassava into a cash crop for urban consumption in Ghana and Nigeria. As shown in Figure 1, while the price of cassava is consistently lower than that of maize for the period 1993 to 2001, the price trends show a similar paradigm for both crops. This established the relationship between the energy sources. On the other hand, the price of wheat which is largely imported is not only consistently higher than maize, but its price fluctuation is largely determined by import policies in Nigeria.

The price trends of maize, cassava chips, soybean meal and groundnut cake in the Nigeria feed milling industry between 1990 and 2002 are shown in Figure 2. For the years 1990, 1993, 1994, 1997 and 2001, cassava chips were not used in the Nigeria feed milling industry because the market price was much higher than giving an economical mix in livestock rations. These periods coincided with the years that followed the cycle of glut when farmers cut back on cassava production following unfavourable market prices. The price relationship of cassava to maize as presented in Table 41 shows that for the years when cassava was used, the percentage of cassava chips to maize varied from 38.9 percent in 1992 to 76.2 percent in 1998. This finding tallies with the recommended prices of cassava in livestock feed in different studies. Reported levels of the price of cassava as a proportion of the price of maize as presented for different countries in Table 42 varies between 60 percent in Nigeria and Thailand and 75 percent in Côte d'Ivoire.

Indeed, in the European Union the feasibility of using cassava as livestock feed largely depends on the prices of protein. Supplements, notably soybean meal, are used to complement the protein of cassava in different mixes. The price of the protein concentrates, soybean meal and groundnut cake as illustrated in Figure 2, shows a rising trend particularly with soybean meal. This is due to stiff competition for this concentrate even in food industries in the country. Full fat soybean is also particularly useful in the cassava mixes used in the Nigerian poultry industry as its high oil content dowses the dustiness of cassava in the compounded rations. The rising price trends of the protein supplements therefore call for greater efforts to reduce the cost of cassava chips for the feed milling industry if it is to compete favourably as a substitute for maize or other cereals. Current studies by Tewe and Bokanga (2001) demonstrated the feasibility of producing cassava chips at market prices 40 percent lower than maize.

Fig. 1. Market prices of Maize, Cassava tuber, Soybean, Shelled groundnuts and Wheat in Nigeria(1993-2001)

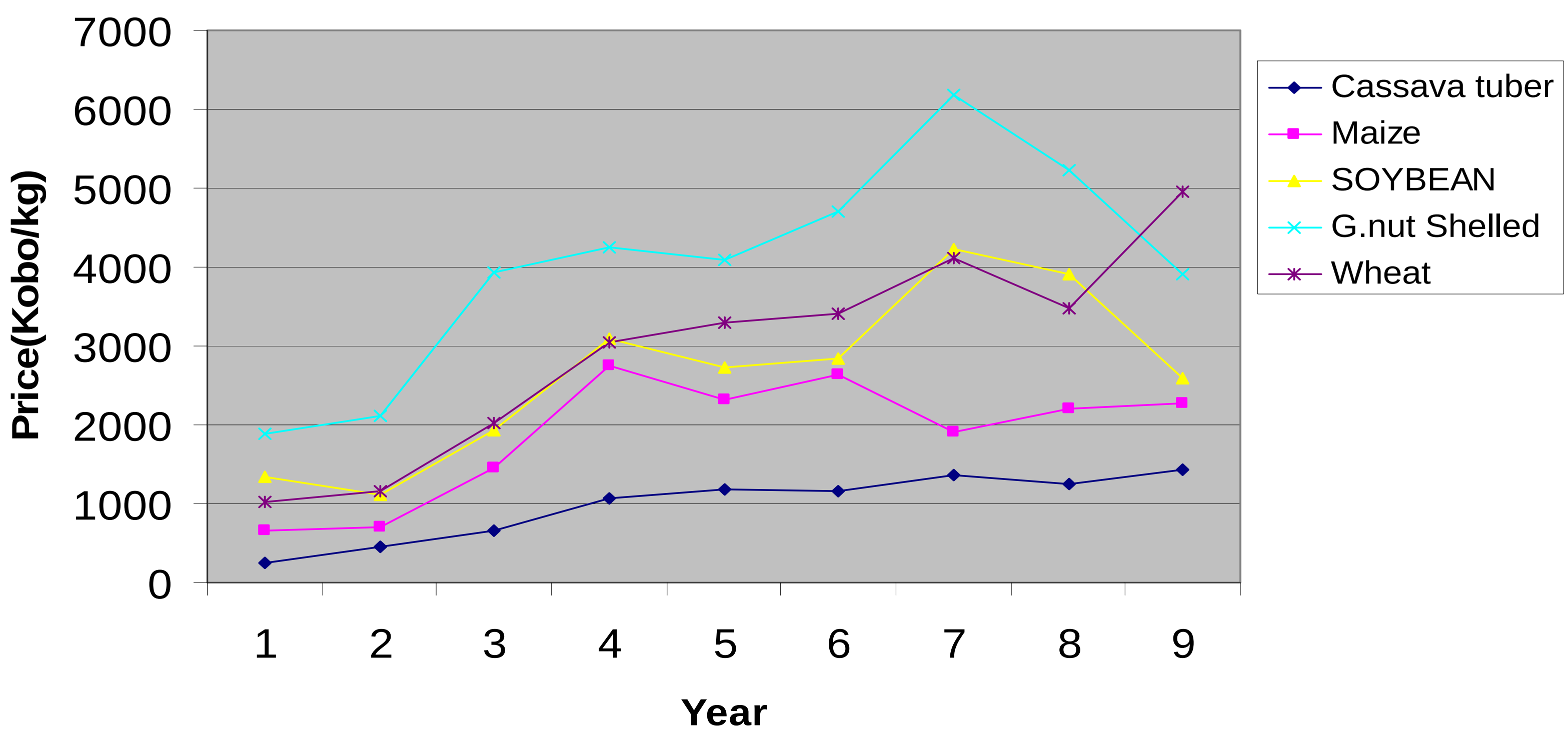

Fig. 2. Price trends of Maize, Cassava Chips, Soybean meal and Groundnut cake in Nigeria's Feed Mill Industry (1990-2002)

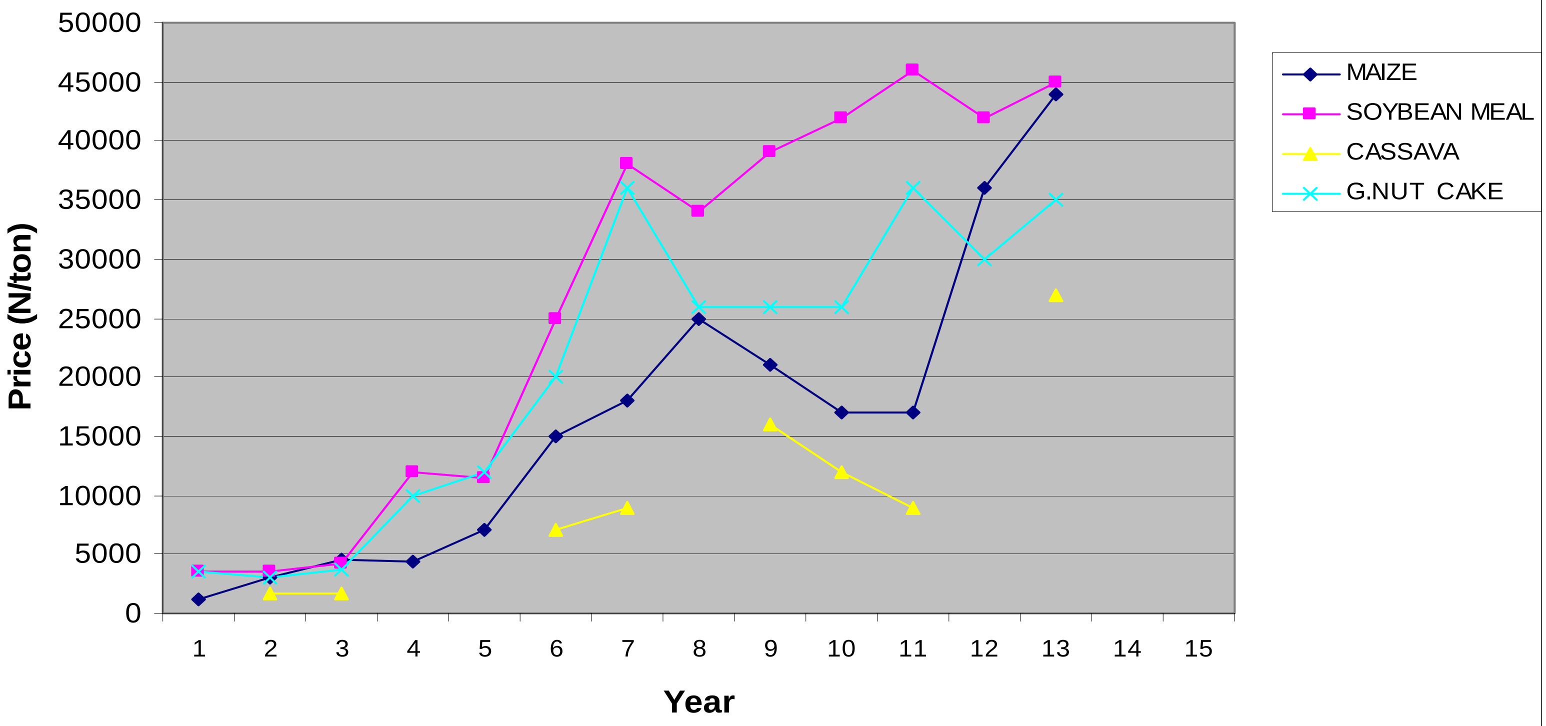

Table 41. Cassava chip prices as percentage of maize price in Nigeria (1990-2002)

1990	N/A
1991	53.3%
1992	38.9%
1993	N/A
1994	N/A
1995	46.6%
1996	50%
1997	N/A
1998	76.2%
1999	70.6%
2000	52.9%
2001	N/A
2002	61.4%

N/A = Data not available.

Table 42. Reported levels of the price of cassava as a proportion of the price of maize in different countries

Percentage of maize price at which cassava becomes economical as a substitute for maize	Country of study
60	Thailand
75	Côte d'Ivoire
70	Zimbabwe
60	Nigeria

Source: Tewe *et al.* (2002)

9. FUTURE PERSPECTIVES AND ACTION AREAS TO ENHANCE THE USE OF CASSAVA IN LIVESTOCK FEEDING

9.1 Feed management systems

The traditional extensive system of livestock rearing which pervades most of the livestock sub-sector in sub-Saharan Africa limits the ability of the producer to input supplemental feeding for rearing stock. Only when market opportunities exist, particularly during festivities, do livestock farmers attempt to input supplemental feeding. To ensure stable productivity however, it is critical to practice supplemental feeding even in such extensive systems. The problem of dry season feeding creates a major need for this during such periods as when herbage availability is very low and in some instances non-existent. Pastoralists transport their stock, particularly cattle, mainly on hoof to more humid areas and in desperation to feed stock usually trample on crop farms devastating large hectarage. On such routes, it is usually cassava alone that is found to be still green at such times and hence trampling and feeding on the leaves usually destroy them. A large number of communal clashes, which have been fatal have occurred and is increasing in frequency due to population pressure on land. Cassava by-products, particularly peels from human food industries, sieviates from food and starch industries, leaves and tender stems of cassava can be dried and stored for sale to livestock farmers on transhumance movements to the more humid zones. Supplemental feeding with cassava by-products will also be of tremendous value in settled smallholder or large-scale enterprises where the demand for such feeds increase tremendously during the drier season of the year. The usual phenomenal increase in price of wheat offal during dry seasons in Nigeria is related to the need for large quantities of this as supplemental feed.

Livestock in sub-Saharan Africa and cattle, sheep and goats in particular depend largely on pasture from rangelands. In addition to acute shortage in the drier season, the quality of forage is usually highly fibrous and of a very poor nutritional value. Such roughages therefore need to be supplemented particularly with energy sources for their efficient utilization and improved productivity of stock throughout the year. Cassava storage roots and residues in the form of peels and sieviate from food and starch industries can serve as readily available sources of energy particularly in partial or totally sedentary systems as has emerged with cattle pastoralists in recent times. The feeding of cassava and cassava residues needs however, to be properly synchronized with that of forage to take advantage of the high degradability of cassava in ruminant rations.

While the poultry and pig populations on the continent are traditionally managed to a large extent, pig and poultry enterprises show the greatest promise presently for commercial, intensive production systems. Cassava root is used in dried or fresh forms on small- and medium-scale pig farming enterprises with such pig farmers depending largely on cassava grown on their farms and supplementing their supplies with cassava purchased from neighbouring farms and cassava wastes from homestead processing of cassava into human foods. Scavenging poultry only depend occasionally on cassava wastes from household food processing of storage roots. For commercial feed milling, ruminant feed accounts for only 5 percent of production in Nigeria. Feed for commercial poultry on the other hand accounts for over 90 percent of total feed production while for pigs the proportion can be up to 3 percent (Tewe, 1997).

Cassava root meal can replace all of the maize in pig and poultry rations provided it is balanced with nutrients in which it is deficient and its dustiness is controlled. Pelletizing is recommended to enhance intake and nutrient utilization. Dried cassava leaves can be used to enhance nitrogen and carotene content of such compound feeds.

Cassava production systems need to explore the use of drought resistant, dual purpose varieties with high foliage yields and greenability of leaves to enable harvesting substantial quantity of leaves in addition to storage roots in mixed farming systems and in the production of cassava root and leaf composite meals and pellets for commercial feed millers. Cropping system strategies to increase the foliage and storage root yield per unit land area also need to be put into place.

9.2 Processing and utilization

The objectives for processing of cassava for livestock feeding include:

- extending the shelf life of the crop for safe storage;

- ease of handling and marketing;
- improvement of the acceptability and palatability of cassava-based diets; and
- maximizing the nutritive component and reducing toxins and contaminants.

Solar drying appears the most practicable and economic means of extending the shelf life of cassava products. The moisture content should not exceed 14 percent and can be stored in jute bags or milled and stored in sealed polythene bags for future use.

Shelf life in room temperature for cassava flour is four to five months, while chips can be stored for up to eight months (Ravindran and Kenkpen, 1992). Pellets last between eight to twelve months depending on if they are soft or hard pellets. Nigeria's major feed millers store chips for not more than three months to guarantee freedom from microbial infestation particularly for commercial poultry feeds.

In processing cassava into pellets, differentiation needs to be made for production of soft pellets suitable for farm or domestic usage and hard pellets suitable for large-scale industrial and export markets. Pellets confer the advantage of reduction in volume during transportation and reduction in dustiness of cassava products. Hard pellets also have the advantage of adequate heat treatment with resultant gelatinization of starch and improved utilization in animals. It is noteworthy that locally fabricated manually and motorized pelletizers used at the IITA in collaboration with the University of Ibadan, Nigeria have not addressed the issue of hardness of pellets and its effects on storability and utilization. Pellets exported to the European Union from Indonesia and Thailand are usually sprayed with oil to reduce dustiness. The cassava is also unpeeled in most instances thus reducing cost of processing. Moreover, starch residues are thus incorporated reducing the cost of final pelletized products.

Improvement in acceptability of cassava diets requires a reduction in dustiness and heat treatment of its starchy components. Cassava root flour-based diets should be mixed with oil seed concentrates like full fat soybeans to reduce dustiness. Pelletizing takes care of both factors. It is important to differentiate between pelletizing of cassava meal and pelletizing cassava-based feeds. The latter will entail steaming and pelletizing all feed components including cassava while the former involves only pelletizing of the cassava and its products. The need to reduce cost of pelletizing cassava to enhance its competitiveness in the domestic and export market is critical. Methods whereby cassava chips are first milled and then steamed before production of pellets might be more expensive than pelletizing crushed and dewatered root and or leaf meals directly before drying. Standards for chips and pellets imported into the European Union as shown in Table 38 indicate levels of hydrocyanic acid of not more than 100 ppm. Level of aflatoxin tolerable is 0.05 mg/kg or less.

The unit operations in processing cassava to animal feeds include chipping, grating, shredding, fermenting, drying, pelletizing and packaging. Fermentation is optional depending on the cyanide content of the raw material used. Pelletizing is also not common in domestic usage of livestock feeds. Wilting of cassava leaves is desirable in the feeding of ruminants. Short-term wilting (three to four hours) of cassava leaves gives toxic levels of HCN, but 48 hours wilting is safe.

The level of contaminants and toxins in cassava products can be very important in cassava chips produced as this varies with the period of drying and cleanliness of the environment. Methods of drying as developed by the Post Harvest Unit of IITA recommend optimum chip size (3 x 7 mm) and loading capacity (5 kg/m^2) on clean concrete floor which can reduce moisture content from 60-70 to 13-14 percent a day during the dry season. Shredding of cassava storage roots and leaves and constant turning can ensure drying to less than 14 percent in 72 hours during the wet season. There is however, a need to test this under varying environmental conditions.

9.3 Marketing of feed and livestock products

The price competitiveness of cassava products as a replacement for maize or wheat in livestock feeding remains the major bottleneck to its widespread adoption in domestic and export markets. Experience from South Africa shows the feasibility of using modern agronomic techniques with supply of inputs under contract arrangement to produce cassava at US$20/tonne as compared with an average price of US$50/tonne with traditional cultural practices in Nigeria. The reduction of production cost is therefore primary to expanding the market for cassava usage in the livestock industry. Farm gate processing is also important to reduce transportation costs thereby transporting dry chips and pellets rather than the fresh storage roots, which also deteriorate rapidly between harvesting and transportation to processing sites. Processing whole unpeeled storage roots into animal feeds will reduce the cost of peeling. A study by Tewe and Bokanga (2001) showed the price of cassava products from unpeeled storage roots and leaves to be 40 percent cheaper than maize.

The poor storability of dried cassava products also limits its usage to short periods when prices are competitive and cassava is produced in abundance. Chips are stored for not more than three months by commercial feed millers in Nigeria. Extending the shelf life will allow its procurement and storage when prices are low and can be competitively used with escalating prices of maize.

The need for promotion of appropriate cassava-based formulations, processing technologies and livestock husbandry systems to optimize performance and profitability of cassava-based feeds in different agricultural settings for mixed (crop/livestock) and livestock farmers in sub-Saharan Africa cannot be over-emphasized. Escalating prices of livestock products in the last decade have been largely due to scarcity and astronomically spiralling costs of livestock feed ingredients, which constitute between 60 and 80 percent of cost of production in commercial livestock production systems. Cheaper cassava-based feeds can therefore stem this tide of animal protein scarcity and its chronic deficiency on the continent.

9.4 Policy issues

Cassava is at different stages of transformation in countries of sub-Saharan Africa. While it is still a staple food in most countries, it is presently a cash crop for urban consumption and food export notably in Ghana and Nigeria. To shift cassava to being a livestock feed for domestic and export markets, the policy issues which need to be implemented are as follows:

- cassava production needs to be modernized. Its traditional systems of production in small hectarages cannot sustain an industrial market. There is a need to drive down the cost of cassava production per tonne in order to give this crop the price competitiveness it requires in comparison with maize and other cereal crops. The need therefore is to recognize the relative neglect that cassava has had in comparison to cereal crops in terms of research development activities. Cassava production has been promoted largely through special projects since independence in many countries, rather than through the systematic improvement of the productivity of the entire cassava food system. It is important to adopt a policy whereby African and donor attention is focused on support for the entire cassava production processing and utilization system to accelerate cassava transformation to an industrial crop in sub-Saharan Africa;
- while the debt burden and unfavourable currency exchange in many African countries have influenced government policy of looking inwards for its food and feed raw material supplies, the inconsistent policy of banning and unbanning importation of non-cassava foods has affected the cassava economy in many African countries. A fundamental problem is the need to remove subsidies on imported maize and wheat in order to provide a level ground for cassava to compete in the food and feed industries;
- the varied levels of transformation of cassava in countries of sub-Saharan Africa create a need for injection of varying technologies in different regions. In West Africa particularly in Nigeria and Ghana, cost saving devices exists for chipping and pelletizing cassava into animal feeds although there is still the need to perfect and disseminate these technologies as developed through the IITA, Ibadan, Nigeria. There is also the need in these countries to diffuse labour saving technologies for production and harvesting of cassava. Diffusion of information on the suitability of whole unpeeled cassava roots for livestock feeding against the use of peeled roots will reduce labour costs and drive down cost of cassava chips and pellets for the feed industry. The adoption of white-skinned and thin-peel varieties will also enhance this cost reduction strategy. In other regions of sub-Saharan Africa, there is a serious need for diffusion of information on mechanized production and processing.

Diffusion of information on cassava-based feed formulation and on-farm data on performance of livestock and fish reared on these diets need to be widely disseminated and demonstrated on the continent. Technologies of incorporation of cassava leaves into feeds also need wide dissemination. Developing the bulking system and collection centres for cassava supply to industries is seriously hampered by poor rural infrastructure. There is a dire need for improvement of rural roads and transportation systems in most sub-Saharan African countries. Development of information technology is critical in accessing market information locally and globally. Cassava farmers therefore need the Internet connectivity to enable them to take advantage of domestic and export market opportunities.

The erroneous notion that cassava is a women's crop has been recently debunked by Nweke *et al.* (2002). Cassava needs to be seen as a crop that provides opportunity for poverty alleviation for both men and women. Indeed as cassava becomes industrialized both men and women become visible in the mechanized production and processing scene.

It is therefore necessary to take a holistic approach and introduce modern systems for production and processing of cassava to drive down its cost and affect its competitiveness with cereals in the livestock feed industries of sub-Saharan Africa.

9.5 Capacity building

The history of cassava development in Africa shows the dearth of scientific capacity that has spanned the period between 1935, when cassava research began at the Amani Research Station in United Republic of Tanzania, and the present in different research and development centres of the continent. The lack of incentives and serious under-funding of most research stations on the continent had dampened the enthusiasm of the few researchers committed to cassava development. Yet, due to the long-term growth cycle of the cassava plant relative to maize, breeding research, in particular, takes a longer time for cassava.

Livestock research and adoption on the continent has also suffered a similar fate. A World Bank Study in Nigeria on the impact of developed livestock technologies on their adoption by farmers (Shaib, Aliyu and Bakshi, 1997) revealed that while there were numerous crop production technologies adopted and disseminated in the 25 years of the World Bank Assisted Agricultural Development Project (ADP) operation in Nigeria, only within the last decade was the issue of livestock technologies addressed to a limited extent. The rate of adoption of developed livestock technologies was also disastrously low. Similar stories were obtained in most other African countries operating the World Bank Assisted ADP scheme.

Due to the low ratio of extension agents to farmers on the continent coupled with under-funding of extension services, poor rural roads and mass illiteracy, development of human capacity for cassava production, processing and marketing has been greatly hampered. Capacity building for cassava development on the continent must therefore take cognisance of the need for researchers, extensionists and practitioners i.e. cassava farmers and processors and would be industrialists. The need to institute private-led initiatives in capacity building is underscored by recent experience in South America where the CLAYUCA consortium serves as an arrowhead for private-led initiatives in cassava development. The need to target cooperative farmers and processors of cassava in capacity building is also critical to its industrialization.

9.6 Environmental considerations

Traditional processing of cassava into food in sub-Saharan Africa is often associated with the discharge of large amounts of water, hydrocyanic acid and organic matter in the form of peels and sieviates from pulp as waste products. These are often improperly disposed and when they are carried out on a large-scale, as in commercial ‘garri’ production, the resulting wastes are often left in mounds which generate a highly offensive odour and are rather unsightly. Cassava processing is therefore generally considered to contribute significantly to environmental pollution and depletion of water resources as they contaminate surface water particularly during the dry seasons of the year.

Traditional cassava processing in Africa is usually carried out around homesteads and closely associated with rearing of sheep, goats, chickens and at times pigs. These stocks therefore consume a substantial part of these wastes in the form of peels, sieviates and often leaves. Indigenous stock reared around homesteads therefore, helps to reduce environmental pollution from cassava waste. It is also a common sight to find roaming indigenous cattle, sheep and goat aggregating around large mounds of cassava peels in cassava food processing centres consuming some part of the generated wastes. An organized collection of cassava wastes particularly the peels and pulp wastes and their proper processing into dry cassava products, can serve as useful supplementary feed particularly for ruminants in sub-Saharan Africa. Indeed, this is the most practicable form of utilizing cassava for livestock feeding in scenarios where cassava storage roots are still insufficient as human food. Cassava processing into commercial livestock feeding presently involves peeling of cassava storage roots and sun-drying. While the peels are left to rot, the drying of the storage roots into chips does not entail discharge of water, which is removed by solar drying. Hence, the risk of cyanide discharge into surface of water is also eliminated and such processing sights are less unsightly. The more recent introduction of producing cassava chips and pellets from whole unpeeled storage roots with incorporation of leaves (Tewe and Bokanga, 2001) eliminates the problem of waste disposal as unpeeled storage roots and leaves are shredded and sun-dried. This is therefore an environmentally friendly method of cassava processing and reduction of waste disposal problems. It is also important to note that processing of cassava into pellets in Thailand often involves incorporation of pulp wastes particularly from the starch industries. Adoption of this in Africa will help reduce waste in food and starch industries. Moreover, wastes from ethanol industries contain protein rich yeast containing by-products. These are often left to discharge in surroundings of industries using cassava for ethanol production as in Nigeria. These protein rich by-products can serve as very useful complements to energy rich cassava storage roots in rations and supplements for different livestock species if the wastes are properly harnessed through drying and proper storage. Use of cassava by-products for livestock feeding can therefore be a major means of recycling wastes into wholesome livestock feeds in Africa.

The advocacy for the use of cassava leaves as animal feed is challenged by the fact that in cassava production systems the leaves are usually left to rot in the field. In this case, returning leaves and stems to the soil is the essential first step in preventing nutrient depletion and maintaining soil fertility. Indeed, in areas where leaves and stems are utilized and removed from the field, nutrient removal can double or triple, depending on whether it is nitrogen, phosphorus or potassium that is considered (FAO/IFAD, 2000). However, where animal manure is available it is recommended to apply about 5 tonnes/ha manure together with chemical fertilizers high in potassium where chemical fertilizers are not available or too costly, it is recommended to apply 7-10 tonnes/ha of manure in combination with wood ash. Mixed farming systems involving rearing of livestock and cultivation of cassava can therefore be an environmentally friendly and fertility sustaining system as the manure from livestock can be very useful in maintaining soil fertility while the cassava leaves peel and pulp wastes or even the storage roots can serve as valuable livestock feed.

Due cognisance must be taken of the hydrocyanic acid discharge from cassava food processing industries. Sheep and goat drinking from cassava polluted water has resulted in some mortality. It is therefore important to ensure that cyanide that is liberated during cassava processing especially in processes that create large amounts of “squeezed juice” should be diluted or stored in such a manner that cyanide concentration is reduced before discharged into the environment. Indeed, models for utilizing waste water from garri industries presently advocate recycling into starch factories where the residual starch can still sediment and be collected before discharge of the effluent into the environment. It should be noted that considerable cyanide can be lost even if storage of such waste water is for a short time.

9.7 Issues for further research and development

While the paltry use of cassavas for livestock feed in Africa is of concern in the quest to develop this root crop as an industrial raw material, the proportion of waste from cassava production presently generated in some countries calls for a closer study of cassava and exploration of its potentials in such places. The proportion of usage for feed in Cameroon, Madagascar and Uganda surpassed that for Nigeria between 1991 and 2000. Yet, these countries are not recognized for their potential to use the crop for livestock feed. That of Cameroon is more interesting as the use of cassava at 150 000 tonnes annually far exceeds the use of maize, which stands at 5 000 tonnes. The example in Nigeria is much publicized, though its rise from 3 percent usage to 10 percent between 1985 and 1990 and subsequent fall to 5 percent between 1991 and 2000 has little explanation; it is probably due to a combination of factors of policy, competitive price and population of livestock particularly poultry during these periods. The ban on maize in 1984 subsequently popularized cassavas for livestock feeds. However, from 1990 non-competitive prices of cassava and the sharp drop in commercial poultry population from 20 to 8 million reduced usages from 10 to 5 percent between 1991 and 2000. Country studies therefore need to be initiated in these places with some potential as indicated, to further exploit it usage for livestock feeding and understand its dynamics as models for other African countries. Products from cassava-based feeds need to be studied in comparison to maize-based ones in these countries in order to obtain comprehensive information on cassava competitiveness and marketing. A review of policies to enhance competitiveness of cassava as compared with maize also needs to be undertaken in many African countries as cereal importation is still highly subsidized.

Due to the cultural practices for cassava production in most African countries, being produced on small hectarage in traditional farming systems with minimal inputs and implements, the cost of production per tonne is much higher and the volume that can be supplied for industrial usage is rather restricted compared with modern production systems as presently adopted on a 5 000 ha cassava farm in South Africa. For competitive processing of cassava in livestock feeding for domestic and export markets, modern cost and labour saving production methods need to be adopted in sub-Saharan Africa. There is therefore the need to develop such practices. Similarly the development of organized bulking and collection centres to feed livestock and other industries needs to be put into place.

Cassava processing methods for the production of chips and to a lesser extent pellets in sub-Saharan Africa are at stages of infancy. Production of chips is by cutting into slices with cutlass or a sharp knife and sun-drying on bare ground or rocky areas in most instances. The cassava is also usually peeled thus increasing cost of production. The quality of such chips also hardly meets the requirement as indicated for the European Union market and compromises standards for domestic feed milling formulations because contaminants and microtoxins are usually at unacceptable levels. Processing techniques developed particularly in collaborative studies between the IITA and the University of Ibadan need to be introduced for adoption on the continent whereby chippers and shredders are used and hygienic conditions are maintained in drying areas. Use of unpeeled storage roots as in these reported studies will eliminate peeling costs and incorporation of leaves will enhance the protein and carotenoid content of such products.

Pelletized products developed from locally fabricated pelletizing machines are still of inferior quality to those acceptable for export markets as soft rather than hard pellets are obtained and the starch is still rather powdery rather than being gelatinized. Yet the cost of imported pelletizers still remains unaffordable for cassava farmers and processors in most instances. The need to source affordable and suitable pelletizers for acceptable cassava pellet products remains to be addressed on the continent. The process of first producing dried chips before pelletizing still raises the problems of remilling and rehydration before pelletizing. Techniques need to be developed to eliminate the need for drying fresh grated or shredded roots before pelletizing to reduce costs and enhance production efficiency. The need to develop efficient dryers for chip and pellets must also be urgently addressed particularly for climate with considerable wet seasons, which coincide with regions of abundance of cassava.

Cassava chips and pellets from Africa have poor storability as microbial infestations set in within three months of storage in most instances. The prolongation of shelf life for cassava products will expand their use particularly in periods of maize scarcity in the livestock industry. Cassava cyanide ‘scare’ is still a problem for its adoption in commercial feed milling. Peeling and sun-drying eliminates most of the cyanide to levels below the acceptable 100 ppm in most instances. Methods of chipping and drying as well as variety differences affect this. With the advocacy for use of unpeeled storage roots for production of cassava chips processing methods need to be standardized and rapid; easy methods for cyanide assay need to be disseminated to ascertain acceptable cyanide levels particularly in dry products.

Livestock production systems in Africa are still largely extensive, yet the demonstrable use of cassava for livestock feeding particularly in the European Union is for the intensively reared stocks. Feeding systems to incorporate cassava as a supplement in extensive and semi-intensive systems need to be developed to take advantage of the need for energy supply in the usually malnourished stock of cattle, sheep and goats reared in such systems.

The development and promotion of cassava plant-based formulations for different livestock and fish species in different countries and agro-ecological settings of Africa is a desideratum if cassava is widely adopted in African livestock feeding systems. The manipulation and promotion of the recommended ration will go a long way to impact this.

On-farm feeding trials to evaluate the performance and economic value of such rations need to be carried out extensively on the continent in order to win the confidence of the commercial feed miller and livestock farmer to adopt them. Their wide publicity after adequate testing will enhance its dissemination and adoption. Establishment of pilot projects to demonstrate the feasibility of such cassava-based feeding systems needs to be instituted in different settings to enhance their adoption.

In a report of the global cassava strategy plan, Spencer *et al.* (1992) commented on the African continent thus:

"Industrialists and entrepreneurs often shy away from using cassava in their applications because of the absence of a local example to follow and uncertainty of success".

Africa therefore needs catalysts which will facilitate cassava feed entrepreneurs and champions who will protect the cassava industry. It is only with this strategy that cassava can take its rightful place in livestock feeding on the African continent.

9.8 Enhancement of food security

Cassava plays a major role in efforts to alleviate the African food crisis because of its efficient production of food energy, year-round availability, tolerance to extreme stress conditions and suitability to present farming and food systems in Africa. In spite of net food importation in Africa as from the early 1970s and food production growing at half the population growth rate from 1970-1985, cassava production in Africa has increased tremendously in the last four decades with Africa producing half of this and Nigeria replacing Brazil as the leading cassava-producing country in the world.

According to Nweke *et al.* (2002), the factors responsible for the dramatic expansion of cassava in Africa are:

- the introduction of the mechanized grater and garri preparation methods that have transformed cassava into a dry cereal for urban consumption;
- rapid population growth and poverty which have encouraged consumers to search for a cheaper source of calories;
- high yielding TMS varieties that have boosted farm level cassava yields by 40 percent in Ghana and Nigeria; and
- biological control of the cassava mealybug.

Yet cassava still remains a traditional staple rather than an industrial crop and it is being discouraged as a low protein food rather than focussing on helping smallholders diversify their crops through industrialization and increase rural incomes so that families can purchase protein-rich foods to supplement their diets.

To satisfy these needs, cognisance should be taken of the problem of glut that usually follows bumper harvests of this crop due to it being used almost entirely for traditional human foods. Diversifying the use of cassava into other commodities in its transformation chain requires standard specifications that will make the cassava product compete favourably in domestic and export markets. Yet these standards can hardly be met with farm gate processing as the rural infrastructure and capability on rural farms are grossly inadequate in most African countries. However, only cassava for animal feed stands a chance of it being used on a large scale as an industrial raw material from cassava as the criteria of standards appear not as stringent as those for other industrial raw material commodities. The required equipment including shredders, chippers and dryers can be fabricated to fit into small-scale enterprises near farming communities. Such dried products can then be transported to urban feed millers or other domestic or export markets. Encouraging farm gate processing of cassava will therefore not only reduce the cost of cassava products due to reduced transportation costs but will also guarantee direct earnings to cassava farmers who hitherto have to contend with ridiculously low prices offered by middlepersons who also have to contend with high transportation costs of fresh cassava storage roots to urban markets. Processing of cassava into dried feed raw material will also enable storage, which is not possible with fresh storage roots, unless they leave this in the ground until needed.

Some countries in Africa currently use between 6 and 27 percent of its cassava production for livestock feeding. The proportion used and absence of use in many African countries is related to its non-competitive pricing relative to maize, which is becoming scarce for the industry due to other competing needs. Yet cassava can occupy this gap if its feed products are made cheaper through:

- farm gate processing to reduce transportation costs of fresh storage root from farms;
- introduction of labour saving equipment to enhance volume produced;
- promotion of cost saving technologies such as use of unpeeled whole storage roots which eliminates peeling costs;
- modernizing production of cassava to enhance productivity and reduce production costs.

Processing of cassava into livestock feed components can therefore expand the market for this commodity and eliminate the cycle of glut that usually accompanies cassava production. The ability to carry out these operations at rural farm level will certainly enhance rural income and create agro-based enterprises, which will help in checking the rural-urban migration.

The ability to purchase other food items to complement their predominantly cassava-based diets will certainly promote health, survival and overall food security of the farming populace in sub-Saharan Africa.

10. SUMMARY AND CONCLUSIONS

Of a total annual production of 87 million tonnes of cassava in Africa, only 6 percent of this is recorded as used in livestock production, mainly in traditional systems for sheep, goats, pigs and chicken reared around homesteads where cassava is processed into food. Commercial usage is limited to poultry and to a lesser extent pig rations. Usage decreases with high cattle density per caput and increases with high commercial poultry density.

Fresh roots contain 60-65 percent moisture, 24-31 percent carbohydrate, 0.2-0.6 percent ether extract, 1-2 percent crude protein and comparatively low content of vitamins and minerals. Dried cassava leaves are a good source of proteins, minerals and vitamins. Recommended nutrient content for cassava chips and pellets for feed are: moisture, 13 percent (max), starch, 75 percent (min), crude fibre, 5.2 percent (max), for peeled roots. Values for unpeeled roots are: moisture, 13 percent (max), starch, 63 percent (min) and crude fibre, 9 percent (max). Tolerable levels of aflatoxin and cyanogens are 0.05 mg/kg (max) and 100 mg HCN equivalent/kg (max) respectively.

Total usage for feed varied in the selected countries from 0-5 percent in West Africa, 0.24-10 percent in Central Africa, 0-27 percent in East Africa and 0-10 percent in South Africa for 2000. No significant change in trend occurred in usage between 1991-2000. In Nigeria an increase from 3-10 percent occurred between 1985 and 1990 but decreased subsequently to 5 percent with the decrease of commercial poultry population from 20 to 8 million between 1985 and 2000 due largely to a raw material feed shortage. Cassava as feed in Cameroon is 150 000 tonnes compared with use of maize, which stands as 5 000 tonnes from 1991 to 2000. Percentage used for feed in East Africa is highest in Uganda at 27 percent. Only Madagascar records cassava usage as feed at 10 percent in South Africa. Wastes from cassava on the continent constitute between 5-52 percent in West Africa, 5-15 percent in Central Africa, 2.7-10 percent in East Africa and 3.1-20 percent in South Africa. This waste is a potential feed resource for the regions.

While research capacity and extension services for livestock development are grossly inadequate on the continent, studies in different countries of Africa confirm the suitability of total replacement of maize or other cereals with cassava root meal in rations for livestock and fish provided there is adequate supplementation with protein, minerals and vitamins, oil supplementation or pelletizing to eliminate dustiness for monogastric feeds, competitive pricing of cassava and reduction in supplementation cost through the use of non-protein nitrogen or poultry manure for ruminant concentrates. Cassava root meal and leaf meals in marsh or pellet form have been used at a 4:1 ratio as maize substitute for poultry and pigs with cost reduction and satisfactory performance. Cassava peels and pulp waste also serve as a readily available energy source particularly for ruminants and to a lesser extent finisher pigs. Cassava usage in commercial feed milling in Africa is largely in the form of dried root chips or marsh as compared with pellets largely used in the European Union. Linear programmed, cost-effective cassava root and leaf meal-based formulations with partial or complete replacement of maize are provided for different livestock and fish species in Africa. A price of between 60-75 percent for cassava products compared with maize is recommended for its competitiveness in feeds.

Competitive pricing of cassava products for feed can be achieved through:

i. reduced processing cost such as use of whole unpeeled storage roots to eliminate peeling costs;
ii. incorporation of wastes including pulp wastes, peels and leaves;
iii. reduced cost and increased efficiency of chipping, drying and pelletizing cassava;
iv. strategic usage for dry season feeding and at periods of maize scarcity;
v. modernizing cassava production to reduce fresh cassava production cost to US$20 per tonne as in South Africa;
vi. steady supply must be guaranteed for export market.

Research and development issues for expanding use of cassava for feed in Africa include:

i. country studies on dynamics of cassava and livestock product trade across seasons;
ii. modernizing cassava production and development of cost effective dryers and farm gate processing to enhance productivity, quality and pricing;
iii. development and promotion of cassava plant-based formulations for livestock and fish in different agro-ecological settings and crop/livestock farming systems of Africa;

iv. establishment of pilot projects to demonstrate feasibility of cassava-based feeding systems.

Environmentally friendly processing techniques to recycle cassava wastes must be adopted and favourable policies such as removal of subsidies on imported cereals will enhance cassava competitiveness and marketing. Expanding cassava usage from its present role of traditional usage for food into a commercial livestock feed raw material is essential to eliminate the cycle of glut (with excess cassava supply), enhance economic empowerment of the continents important rural cassava farming populace and enable them to afford much needed proteineous and other nutrient-rich foods to supplement their predominantly cassava-based diets.

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This publication presents a review of research findings and existing data from micro-sample surveys on cassava usage in livestock feed in selected African countries. It summarizes the livestock production and feeding patterns on the continent and contributes to the better understanding of the competitiveness of cassava as compared with cereals. Strategies for expanding cassava beyond its traditional use as food and its transformation to a livestock feed ingredient in sub-Saharan Africa are recommended. The study will interest a wide range of readers including cassava producers, policy-makers, donors, scientists and technicians.

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