APPENDICES

Appendix 16.1. The F0004 project concept note submitted under the 'Research Continuity Scheme'.

RESEARCH CONTINUITY SCHEME - CONCEPT NOTE

LIVESTOCK PRODUCTION PROGRAMME

The utilisation of sweet potato and cassava root meal in poultry diets

Alignment with Research Strategy

The proposed adaptive research aims to demonstrate that sweet potato and cassava root meals can be economically used at high dietary inclusion rates in the poultry production systems of certain developing countries. It merits priority rating 1 for cassava and 2 for sweet potato on commodities in the RNRRS. As the research concerns the cost effectiveness of providing essential nutrients to livestock using crops and their by-products, residues and wastes, it also merits priority 1 rating under Livestock Programme.

Relationship with earlier NRED-funded strategic research and NRI comparative advantage

The proposed work is a continuation of NRED-funded research at NRI during the 1980's. In that research, commodities were assessed to determine their maximum dietary inclusion rates, and the nutritional reasons for this limit. This is necessary to enable findings to be reliably adapted to the optimal inclusion rates appropriate to specific field situations. Strategic research on some root crops has reached a stage where field research is required to demonstrate the adaptation of experimental findings to specific local situations.

Root crops are one of several classes of tropical feeds (also oilseed cakes, animal wastes) evaluated under the programme, knowledge of this range of feeds is important when formulating least-cost poultry diets. This breadth of experience therefore places NRI in a unique position to conduct this adaptive research.

Geographical context of adaptive/field research

The research will be carried out in two stages: (i) country-specific adaptation trials for sweet potato, to be conducted in UK using raw materials relevant to Cameroon, and (ii) field trials for both commodities at the International Potato Centre (CIP) (Cameroon), which has a research programme on the development of root crops for livestock feeding. Collaboration with CIP will assist in the dissemination of findings, potentially leading to greater uptake in other countries and interest from other donors.

Outputs and Inputs

The project will

(i) demonstrate how appropriately-processed local varieties of sweet potato and cassava can be used in poultry diets at levels up to 500 g/kg,

(ii) evaluate the acceptability of root crops-based poultry diets among local small-scale poultry producers,

(iii) publish a paper to promote the concepts in other developing countries.

Summary of financial support requested from NRED funds

	Year 1	Year 2	Year 3
Personal Emoluments	32,620	23,790	11,010
Travel and Subsistence	0	11,000	4,500
Consumables	8,000	2,000	500
Other charges	0	1,000	500
Total	40,620	37,790	16,510

Applicability of results

Root crops are important resources for feeding livestock in many tropical developing countries, sweet potato and cassava being particularly versatile in their agronomic requirements, giving high yields in diverse climatic conditions. Whereas experimental results indicate that cassava root meal may be included in poultry diets at 500 g/kg without depression of production (NRI's recommendation), it suggests more caution in the case of sweet potato, limiting it to around 200 g/kg diet. Experience at NRI however indicates that the nutritive value of sweet potato may have been underestimated, partly due to inappropriate methodology being used in some of the reported studies: this has resulted in underutilisation of this resource. It is therefore pertinent to conduct adaptive research, using feeding techniques developed at NRI for cassava root meal, to demonstrate the high feeding value of sweet potato in poultry diets, and subsequently, to evaluate the acceptability to small-scale producers of including sweet potato or cassava in poultry diets.

The economic significance of the project lies in reducing the cost of poultry meat and egg production, and by replacing the cereal component of poultry diets with root crops, releasing the former for human consumption. The findings will be of interest to many poultry producers in African, Asian and Latin American countries where both cassava and sweet potato are available for feeding animals. The technique is likely to be immediately available and highly sustainable in view of the recent proliferation of high yielding varieties of sweet potato in developing countries.

Note: Following a prefeasibility study in 1994 to select a suitable project site, the structure of the project and budget were changed to incorporate a sub-component project for field activities (F0060) which was managed by IRZV as an Extra-Mural Contract.

Appendix 16.2. Memorandum of understanding signed by NRI and IRZV in 1992.

MEMORANDUM OF UNDERSTANDING

between

THE NATURAL RESOURCES INSTITUTE

hereinafter referred to as NRI with headquarters in Chatham, Kent, United Kingdom

and

THE INSTITUTE OF ANIMAL AND VETERINARY RESEARCH

hereinafter referred to as IRZV, with headquarters at Yaounde, B.P. 1457, Cameroon

PREAMBLE

Whereas NRI is a scientific agency of the UK Overseas Development Administration with a broad mandate for the improvement of agricultural production and other natural resources in developing countries, specifically in the area of pest management, resource assessment and farming systems, and food science and crop utilisation;

Whereas the IRZV is the Animal Research Institute of the Ministry of Scientific and Technical Research, responsible for all research in Animal Production in Cameroon, with a broad mandate for co-ordinating research in livestock farming systems, breeding/ selection, animal health, fisheries, and biodiversity conservation.

and

Whereas the NRI and the IRZV have common interest in improving live stock production and the utilisation of crop residues and agro-industrial by-products by livestock, and in meat science;

The two parties agree as follows:

Article I

The NRI and the IRZV, to achieve their common goals and to exploit complementarity of skills and expertise, will collaborate generally and exchange information in the areas of interest and mutual benefit stated in the Preamble. In particular, and as a basis for potential developments in other areas of interest, the parties agree to collaborate in the advancement of livestock production.

Article II

The Deputy Director of the NRI and the Head of Resource Assessment and Farming Systems Strategy Area, and the Director of the IRZV will determine the practical details of co-operation between the two organisations and, in general, to ensure the proper and effective implementation of this Memorandum of Understanding. Collaborative activities, current and potential, will be reviewed biennially by these individuals.

Article III

Each collaborative activity between the NRI and IRZV will be defined in a document, which will describe the objectives as well as the details of the responsibilities and activities of either party; this document will be signed by the representatives of the two parties named under Article II, and will be deemed to be an addendum to this Memorandum.

The on-going collaborative activities will be deemed to be covered under this agreement.

Article IV

This Memorandum of Understanding will become effective on the date of signature of both parties and will remain effective until either party gives notice to the other of its intention to terminate, provided such termination allows for the orderly completion of any collaborative project which may still be in the process of implementation, in which event the agreement shall stand terminated at the end of six months from the date of issue of such notice.

For the NATURAL RESOURCES INSTITUTE

_______________________________ Date: ________________

For the INSTITUTE OF ANIMAL AND VETERINARY RESEARCH

_______________________________ Date: ________________

Appendix 16.3. Poultry farm characterisation study: feed resources and poultry production systems in the mid and high altitude zone of Cameroon.

(Adapted from MRS Report No 13, August 1996 by Dr. R. T. Fomunyam, Dr. D. K. Poné, E. N. Ntumgia. The study was conducted at the start of the project's field activities to ensure that the feed developmental research fits into the agricultural systems in the project area).

Contents:

Abbreviations used:

AGROCAM	Agro-industrie du Cameroun
CCC	Complexe Chimique Camerounais
EEC	European Economic Community
EPA	Elevage Promotion Afrique
FONADER	Fonds National de Développement Rural
IPC	International Potato Centre
IRZV	Institute of Animal and Veterinary Research
KFBL	Kerosene Fuelled Bush Lamp
MESIRES	Ministry of Higher Education and Scientific Research
MINAGRI	Ministry of Agriculture
MINEPIA	Ministry of Livestock, Fisheries and Animal Industries
MINPAT	Ministry of Plan and Regional Development
MHAZ	Mid and High Altitude Zone
NRI	Natural Resources Institute
ONDAPB	Office Nationale de Développement de l'Aviculture et du Petit Bétail.
OPV	Veterinary Pharmaceutical Office
PRTC	Presbetarian Rural Training Centre
SAC	Société des Aviculteurs Camerounais
SCM	Société Camerounaise de Minoterie
SODECOTON	Société de Développement du Cotton

SODEPA	Livestock Development Corporation
SPC	Société des Provenderies du Cameroun
STV	Société de Transformation des Volailles

Introduction

The Republic of Cameroon has a population of 10.5 million people (Population Census, 1987) and covers an area of 475,000 km². Six major agro-ecological zones have been described as shown in Map 1: the Sahelian (Zone I), covering the Far North and North Provinces; the Sudano-Guinean Savanna (Zone II) of the Adamawa Province; the Mid and High Altitude Savanna (Zone III) of the West, North West and part of the South West Provinces; the Humid Forest (Zone IV) of South West and Littoral Provinces; the Sub-Humid Forest (Zone V) of Centre and South Provinces; and the Sub-Humid Savanna and Forest (Zone VI) of the East Province. Table 1 shows the principal characteristics of each zone.

The bread basket of the nation is Zone III, the Mid and High Altitude Zone (MHAZ) (Map 2). The major food crops in the zone (Table 2) are maize, banana and plantains, beans, cassava, Irish potatoes, sweet potatoes, cocoyams and yams. The major livestock (Table 3) are pigs, rabbits, chickens, cattle, sheep and goats. The farming system integrates crops and livestock. It has been estimated that an average farm in the zone has 26 cattle, 8 goats, 9 sheep, 3 pigs, and 13 chickens (MINAGRI, 1984). This zone in 1989/90 had 80 % of rabbits, 43 % of poultry, 40 % of pigs, 18 % cattle and horses, 17 % of sheep, and 12 % of goats in the total national livestock population. Within the zone itself, Donga Mantung division has the largest sheep population, while Menchum has the largest cattle stock. Goats and poultry are mostly found in Menoua division, while pigs and rabbits are intensively raised in Mifi division.

The MHAZ produced 59 % (1980-81), 37.7 % (1983-84), 47.2 % (1986-87) and 43 % (1989-90) of the national chicken population. Poultry is predominantly kept in Menoua and Mifi Divisions (West Province) while in the North West Province, they are found mostly in Mezam and Ndonga Mantung Divisions.

Poultry is estimated to yield about 13,000 tons of meat yearly. Annual poultry meat and egg consumption averaged 1.0 kg and 14 eggs of 50 g per capita. This means that each Cameroonian eats about 3 g of poultry meat and 2 g of fresh eggs daily. In 1984, meat and egg represented 1.38 % and 0.61 % of each urban household food budget (DSN, 1984). This figure is low and represents 12 % of the national annual per capita animal protein intake.

It was with this background that the feeding of chickens specifically energy sources in chicken diets was chosen for research in a collaborative study between the Natural Resources Institute (NRI) in the United Kingdom (UK), IRZV, IPC and extension ministries in Cameroon. This project fits well with IRZV's development goals aimed at increasing productivity in the poultry sector. In this regard an analysis of the poultry production business in the Western Highlands of Cameroon in particular and Cameroon in general has been undertaken.

Table 1. Economic and environmental indicators in the agro-ecological zones of Cameroon.

Agro-ecological zones:	Sahel zone	Savanna zone II	Mid and High Altitude savanna zone III	Humid Forest zone IV	Sub-Humid Forest zone V	Sub-Humid Savanna and Forest zone VI	
Provinces:	Far North/ North	Adamawa	North West/West	South West/ Littoral	Central/ South	East	
Criteria:							**Total**
Altitude (m)	400-800	>1000	700-1900	0-800	<80	300-800	
Population density	Medium	Low	High	High	Medium	Low	
Rainfall (mm)	400-1000	1000-1500	1500-2500	>2500	1500-2500	1500-2500	
Land area (km^2)	101,603	61,992	31,190	45,130	116,132	108,540	464,587
(%)	21.9	13.3	6.7	9.7	25.0	23.4	100.0
National parks and equivalent reserves (ha)	909,000		5,970	290,000	303,000	843,000	2,350,970
Climatic risks to agriculture	Very high	Low	Medium	Medium	Low	Very low	
Erosion/land degradation	Very high	Medium	High	Medium	Medium	Low	
Population	2,335,000	423,000	2,552,000	2,502,000	2,159,000	476,000	10,447,000
Population density (km^2)	23.0[1]	6.7	81.8	55.4	18.6	4.4	22.5
Urbanisation (%)	14.0	22.6	22.4	60.8	37.9	24.0	30.3
Average gross income per farm FCFA	159,000	167,000	356,000	813,000	424,000	253,000	180,000
From:							
Export crops (%):	43.1	13.0	40.4	66.2	67.3	57.6	51.2
Food crops (%)	27.1	63.3	49.9	32.2	31.0	40.5	40.3
Livestock (%)	29.8	18.7	9.7	1.6	1.7	1.9	8.5
Livestock population (1986/87)							
Cattle	1,657,400	1,587,500	777,300	16,500	46,300	276,500	4,361,500
Sheep	1,362,600	139,000	406,000	34,200	166,300	250,000	2,358,100
Goats	1,507,300	84,900	695,000	56,000	307,100	267,200	2,917,500
Pigs	53,000	2,000	400,000	190,000	95,000	60,000	800,000
Poultry	1,867,000	194,000	3,054,000	2,393,000	6,014,000	478,000	14,000,000

1. Far North: Population density 95.1/Km^2, North population density 8.8/Km^2.Source: Cameroon Agricultural Sector Review, March 1989.

Table 2. Crop production in the MHAZ (tons).

Food crop	North West Province	West Province	MHAZ total	MHAZ as % of national
Maize	212,460	139,973	352,430	68.3
Banana	110,715	154,688	265,403	56.0
Plantains	168,275	128,809	297,084	73.2
Cocoyams	202,139	54,706	256,845	81.5
Cassava	124,696	106,049	230,745	59.3
Sweet potato	24,151	48,200	72,351	25.1
Yams	20,223	20,694	40,917	-
Irish potato	20,763	12,693	33,456	77.6
Beans	24,943	16,854	41,797	
Groundnuts(shelled)	15,191	13,963	29,154	33.0
Rice	2,378	5,164	7,542	69.5
Palm oil	12,343	6,567	18,910	43.0
Sugar cane	16,407	23,973	40,380	
Palm kernel	nd	23,091	23,091	

Notes: - nd: no data. Sources: MINAGRI: Annual reports, West Province; MINAGRI: Annual reports, North West Province.

Table 3: Livestock population in the MHAZ and their relative importance nation wide.

Division	Cattle	Sheep	Goats	Pigs	Poultry	Rabbits[1]	Horses
Bui	72,000	32,600	31,500	1,700	97,600	1,540	860
Donga-Mantung	148,300	86,000	18,700	2,300	145,000	1,320	760
Menchum	149,600	21,200	12,700	6,500	79,400	3,600	830
Mezam	72,100	16,500	18,500	7,800	310,750	5,545	480
Momo	30,500	8,600	10,400	11,400	68,150	1,000	276
North West Province	472,500	164,900	91,800	29,700	700,900	10,665	3,206
Bamboutos	18,662	8,203	9,399	16,481	126,320	266	256
Menoua	6,375	52,060	74,163	54,079	2,466,500	567	1,284
Mifi	3,818	21,856	30,625	130,274	602,912	13,860	16,835
Ndé	5,554	11,240	37,805	8,375	143,896	116	6,195
Noun	84,144	42,682	26,353	331	163,772	117	597
Upper-Nkam	1,067	8,290	7,599	13,738	121,550	1,115	939
West Province	119,620	144,331	185,944	223,278	3,624,950	16,041	26,106
MHAZ total	592,120	309,231	277,744	252,978	4,325,850	26,706	29,312
% of the nation total	18	17	12	40	43	80	

Sources: MINEPIA, Rapport annuel, Province Ouest: 1989/90; MINEPIA, Annual report, North West Province: 1989/90. 1 Heifer Project International report, 1990 (for NWP only)

2.0. Methodology

The survey on the characterization of poultry production systems was carried out in the MHAZ. One hundred and six (106) commercial poultry farms were surveyed and 102 poultry houses evaluated for management parameters. A clustering sampling technique was used to select six administrative divisions, three in each province taken separately, based on official statistics on poultry population. The Divisions were Mifi, Menoua and Bamboutos (West Province) and Mezam, Bui, and Donga Mantung (North-West Province).

Using a pre-tested questionnaire, data were gathered on farm age, production capacity, marketing, type and objective of production, and sources of funds. Because of inconsistent official data on the actual number of poultry farmers, a "snowball" sampling technique was implemented with the help of the first identified farmer in each administrative sub-Divisional unit. Visits were also made to government offices, feed mills, slaughter houses, local and major markets within the country for additional data.

A complementary description was provided using existing literature on poultry production under the traditional production system earlier reported in the North West Province of Cameroon by a multidisciplinary team of researchers. Because information herein did not reflect the entire nation, additional literature from other zones of Cameroon was included for comparative purposes.

3.0. Production systems

The MHAZ can be divided into two major farming systems based on land tenure and use pattern as described by Jahnke (1982) and this survey:

1. The extensive pasture-based livestock production system in which the major livestock are large and small ruminant animals, and a few monogastrics mostly chickens; and

2. The semi-intensive to intensive pastureless-based livestock production system in which the major livestock are monogastrics (pigs, poultry, and rabbits) and small ruminants.

Both systems have several minor variations from the above description.

3.1. The traditional poultry sector

This sector also known as the backyard or farmyard system and is characterized by chickens roaming around the farmyard, scavenging for themselves. Apart from containing 63% of the national flock population, the sector is managed (LSRP-Bambui, 1989) by 60% of the nation households. Flock size is small (6-50 birds) and 41% of households keep less than 5 birds (Table 4).

Table 4. Flock size characteristics for back-yard chicken population.

Flock sizes (number of birds)	Number of farms	Proportion (%)
< 5	54	41.2
6 - 20	30	22.9
21 - 50	32	24.4
> 50	15	11.5
Total	131	100.0

Source: LSRP-Bambui (1989).

3.1.1. Breeds and breeding management

(a) Breeds. Chickens found in the back yard are apparently crosses between local strains and introduced hybrids. Phenotypically, the chickens have white skin, red wattles and orange eyes. The plumage colour is of variable colours from a combination of red, white and black. Shanks are predominantly white and non-feathered. The legs have four toes. Sexual dimorphism favoured cocks for all body measurements except for beak length (Fotsa and Poné, 1988).

(b) Breeding management and performance. Farmers usually control breeding by introducing a cock to run with the hens or the hens get served by the cocks in the neighbourhood. Hens wean chicks at any time. A hen broods 3 to 4 times a year and produces 6-10 adult birds per year. Because of loose attention by the farmer, hatchability of all eggs brooded is always low. As shown in Table 5, the ratio of cockerels to pullets stands at 1:1 while at breeding age it declines to reach 1:3. Thus, few cocks are left in the backyard at breeding.

Chickens in this sector are characterized by small body sizes (1.2-2 kg), late maturity (10-12 months) (Table 6), low performance in egg number (80-140 eggs per year), small egg size (35-50 g) long laying pause (90-105 days), and a strong inclination to broodiness (18-28 days) (Douffissa, 1987; Fotsa and Poné, 1988; LSRP-Bambui, 1989).

Table 5. Structure of chicken population in Momo Division., North West Province.

Classes of chickens	Number of chickens	Proportion (%)
Cocks	510	16.2
Hens	1206	38.3
Cockerels	285	9.0
Pullets	338	10.7
Chicks	812	25.8
Total	3151	100.0

Source: LSRP-Bambui (1989).

Table 6. Age at first hatching of poultry in Momo division.

	Age range for first hatching (months)			
	<6	6-9	10-12	>12
Percentage of farms out of 19	15.8	31.6	52.6	0.0

Source: Adapted from LSRP-Bambui (1989).

3.1.2. Housing and housing management

Farmers do not generally provide a good poultry house for chickens. Chickens roam about the homestead with minimal attention from the owner. Douffissa (1987) reported that a raised slats housing system prevailed in the Adamawa Province of Cameroon. That house had a conic and thatched roof and the night floor density averaged 12 birds/m^2 (3-72 birds/m^2).

LSRP-Bambui (1989) reported that only 25 % of farmers practised a kind of confinement for chickens. Broody hens and their offsprings were confined for up to three months in the kitchen or in a separate barn, or along the house, while all classes of chickens were confined during cropping season, especially from March to May. Occasionally, chickens were confined and fattened for special cases such as emergency marketing, food and gifts, or for cultural activities.

3.1.3. Feed and feeding management

Apart from food obtained through scavenging, feed for birds particularly energy is often supplemented with household scraps particularly kitchen wastes and weeviled maize. Protein in the diets come from insects and herbage. Herbage and soil supply the minerals and vitamins in the diet. Even if the feed was balanced and adequate a lot of energy is spent scavenging for food.

3.1.4. Diseases

High pre-weaning mortalities (Table 7) i.e chicks survival up to 2-3 months was reported to vary from 30 to 60% (RRAS BUI, 1988). In the Adamawa Province of Cameroon, Douffissa (1987) reported that poultry farmers were loosing about one-third of their flock every year because of various chicken diseases such as Newcastle disease, pullorum and coccidiosis. It was also reported that night shades were of poor hygienic condition and frequently infested with lice. Mite infestation may also be a common problem.

Table 7. Distribution of mortality by age group of poultry in Momo Division.

		Age group		
	Still-birth	Pre-weaned	Weaned	Breeders
Mortality (as % of birds out of 485)	14.6	59.2	4.3	21.9

Source: Adapted from LSRP-Bambui (1989).

3.1.5. Socio-economics

3.1.5.1. Farmers' goals and objectives

Poultry under traditional or backyard system is part of the whole farming system. The goal is to ensure sustained food production and fulfil family needs such as food, clothing, medical care, school fees, and extended family problems.

3.1.5.2. Labour distribution and use

In the rural area (LSRP-Bambui, 1989), husbands contributed 36.4 % of the total labour input for livestock activities. 24.8 % of the labour supply came from children and 21.4 % from women and hired labour (19.2 %) (Table 8).

Family labour accounted for 80 % of the total labour input. Single species such as goats and poultry were managed by adults with 62.2 % and 81.4% of the labour devoted to them, respectively. Hired labour was employed mostly by farmers keeping cattle alone (72 %) or in association with sheep (20%) and to a lesser extent by farmers rearing poultry in association with pigs (10 %). Most of the labour from children was used for rearing goats alone (38 %) or goats and poultry combined (50 %). Livestock association in which pigs and poultry were combined were mostly handled by men (Table 8).

Table 8. Labour distribution according to poultry-livestock association in Momo Division.

Livestock associations	Number of farms	Farm labour (%) Husband	Wife	Children	Hired	
Single species:	176	26.1	24.4	19.3	30.2	
Cattle	68	13.2	7.4	7.4	72.0	
Goats	45	33.3	28.9	37.8	0.0	
Poultry	43	41.9	39.5	11.6	7.0	
Others	20	20.0	40.0	35.0	5.0	
Two species:	79	41.8	15.2	32.9	10.1	
Goats & pigs	16	37.5	25.0	31.2	6.3	
Goats & poultry	16	37.5	12.5	50.0	0.0	
Cattle & sheep	15	40.0	0.0	40.0	20.0	
Pigs & poultry	10	60.0	20.0	10.0	10.0	
Others	22	40.9	18.2	27.3	23.6	
Three species:	57	49.1	19.3	31.6	0.0	
Goats, pigs & poultry	37	51.4	18.9	29.7	0.0	
Others	20	45.0	20.0	35.0	0.0	
Four species:	6	50.0	33.3	16.7	0.0	
Sheep, goats, pigs & poultry		6	50.0	33.3	16.7	0.0
Total count	318	34.6	21.4	24.8	19.2	

Source: LSRP-Bambui (1989).

3.1.5.3. Marketing

Chickens are sold in the neighbourhood either at the farmers initiative or that of the neighbour. Thus, prices vary from 600 francs CFA for 500 g chick to 1500 FCFA for a hen or 2500 FCFA for a cock. Disposal of chickens is also prompted by other cultural activities such as arrival of a guest or birth of a child.

3.1.6. The future of the traditional sector

Despite the many set-backs of this sector of the poultry industry, farmers apparently make some gains or else the system would not continue to exist. It is suggested that a closer study be made with a view to making the system more efficient in terms of resources utilization.

Presently, the sector lives in harmony with the environment due to small flock sizes. Increased production will call for better resource utilization and protection of the environment. A pre-extension project has been initiated at IRZV Mankon to vaccinate chickens and supply feed to farmers in an attempt to reduce losses. A health package which involves vaccination of chickens against common contagious diseases and a feed package which supplies additional energy such as maize, tubers and banana/plantains are being evaluated. A second stage envisages a much improved housing and environmental systems. These improvement techniques are being introduced in a step by step method to minimize stress to the production system. The scope for significantly increasing the output and productivity of the traditional systems is however minimal.

3.2. The modern sector

This sector is characterized by intensive management practices in which housing, imported breeds, compound feeds, and drugs are introduced. Farmers objectives and know-how are related to size, production type, labour and marketing. Contrary to the traditional sector, the modern sector is well-encouraged by the government through establishment of government stations that supply subsidized inputs (MINPAT, VIth Plan, 1986-1991, p.89).

3.2.1. Breeds and breeding management

3.2.1.1. Type of chicken farms

Poné (1990) reported that in the MHAZ, 58% of poultry farmers kept layers, 32% kept broilers, and 10% were engaged in mixed operations with both broiler and laying hen flocks. The proportions of each type vary from one area to another and might be related to periods of the year (Table 9. For example, some farmers only produce broilers at peak demand periods.

3.2.1.2. Breeds

Three companies AGROCAM, SAC, SABEL and to a lesser extent IRZV, GILANN, and ONDAPB import parent stock chicks and/or hatchable eggs from major suppliers in the EEC (France, Belgium, Holland, Germany and United Kingdom), Middle-East (Israel) and USA. Some of the breeds recorded in the field are: Hybro, Jupiter, Derrich, Hubbard, Rhode Island Red, White Leghorn, Cornish, Lohmann, Hisex, ISA White and ISA Brown. The great variability in sources of day-old-chicks imported, also reflects variability in quality of chicks. AGROCAM (56%) and SAC (23%) are the major supplier of chicks.

Table 9. Proportions of broiler and layer farms (%) in different provinces of Cameroon.

Poultry farm type:	**West Province**[1]	**MHAZ**[2]	**Centre and Littoral provinces**[3]	**Centre**[4] **Province**
Broilers	47.8	31.7	37	4.3
Layers	21.6	58.4	3	61.4
Mixed (broiler and layers)	30.6	9.9	60	34.3

Source: 1.Djoukam and Téguia (1991); 2. Poné (1990) - unpublished data; 3. MINEPIA (1987) - registered farms. 4. Epo (1983).

There are fifteen hatcheries operating in the country with an annual total capacity of 20 millions chicks a year. However, between 1988 to 1991 only 4.7 million chicks were produced. Imports accounted for 1.4 million chicks during the same period (Crouail and Duault, 1991). In 1990/91, however, 7 million day-old-chicks consisting of 6.3 millions broiler chicks and 700,000 pullet chicks were sold (Table 10).

3.2.1.3. Breeding management

3.2.1.3.1. Flock sizes

The survey in the MHAZ showed that 87% and 44% of broiler and layer farms had flock sizes below 500 birds. The maximum flock size registered per farm was 8500 layers and 4800 broilers. On average, there were 295 broiler chickens per farm. For egg-type farms, pullets, cockerels and laying birds averaged 409, 24, and 832 birds per farm, respectively. As reported by Djoukam and Téguia (1991), there was a tendency for farmers to take poultry as a principal activity as flock sizes increased above 1000 birds, especially for those engaged in egg production (Table 11).

Table 10. Hatchery capacity and day-old-chick production and/or import (in thousands) in Cameroon.

Hatcheries	Financial year 1988/89	1989/90	1990/91	Hatchery chicks production capacity
AGROCAM	1,963	2,698	2,892	6,240
SAC (AZANGUE)	nd	nd	1,520	3,780
GILANN (KADJI)	nd	nd	300	2,000
ONDAPB Douala	710	402	159	2,000
ONDAPB Yaoundé	644	391	188	2,000
ONDAPB Muyuka	nd	nd	54	300
ONDAPB Kounden	44	116	131	200
SABEL Yaoundé	nd	nd	nd	3,000
Monastery Mbengwi	nd	nd	nd	156
IRZV	10	6	4	220
Others	600	500	700	nd
Total production	3,971	4,113	5,948	19,896
Total imports	1,521	1,725	1,057	
Total chicks available	5,492	5,838	7,005	
Imports of hatchable eggs[1]	842	1,124	2,000	

Notes: 1. Hatchable eggs are imported during peak day-old-chicks demand periods (October-November); nd: not determined; Sources: Crouail and Duault (1991); Batimba and Mewoand (1992); IRZ Mankon (1988).

Table 11. Comparison of type of chicken and flock size on farms where farmers keep poultry as a principal activity.

Farm flock size (birds)	Type of production (% given in brackets) Broilers only	Layers only	Broilers & layers	Total
<500	1 (8.33)	-	-	1 (8.3)
501-1000	1 (8.33)	1 (8.33)	-	2 (16.7)
1001-2500	-	3 (25.0)	-	3 (25.0)
>2500	-	5 (41.7)	1 (8.3)	6 (50.0)
Total	2 (16.7)	9 (75.0)	1 (8.3)	12 (100)

Source: Djoukam and Téguia, 1991

3.2.2. Houses and housing systems

A total of 252 poultry buildings were identified on 92 poultry farms. 40% of the surveyed houses were used for broiler production and 60% for egg production. 59% of broiler houses were used for separate building activities such as brooding (38%) and growing (21%), and 41% of them were used in all-in-all-out practice. For the pullet houses, 53% were used for growing-laying activities (Table 12).

Table 12. Distribution of housing systems according to management activities.

Management activities	Number of buildings	%	Overall
Broiler houses	100	100.0	39.7
Brooding only	38	38.0	
Brooding-growing	41	41.0	
Growing only	21	21.0	
Pullet houses	152	100.0	60.3
Brooding-growing	3	2.0	
Growing-laying	80	52.6	
Laying only	6	4.0	
Brooding-growing-laying	63	41.4	
Total	252	-	100.0

Source: Adapted from Poné (1993).

Three types of housing systems were identified based on flooring systems: deep litter, raised slats, and battery caging. 79% of the floors were of the deep litter system (Table 13). 77% of farmers conceived and designed their poultry houses, while about 17% did so using available poultry manuals (Table 14).

Table 13. Frequency distribution of housing systems according to floor type.

Floor type	Number of houses	Percentage
Deep litter system	199	79.0
Raised bamboo slats system	49	19.4
Battery caging system	4	1.6
Total	252	100.0

Source: Poné (1993)

Table 14. Poultry house designer, as percentages of surveyed respondents.

Designer	Number of farmers	Percentage
Poultry farmer conception	78	76.5
Poultry farmer using manuals	17	16.6
Poultry specialist	7	6.9
Total	102	100.0

Source: Poné (1993)

Table 15 shows that 49.5% of poultry houses were less than five years, 37.6% were between 5 to 10 years, and 12% 10 years and older. The raised bamboo floor house was newer in design than the deep litter house, with 95% versus 85% of the houses being less than 11 years old.

Table 15. Age distribution (%) of poultry houses according to floor and chicken types.

	Number of houses	Age of poultry house (years) <5	5-10	>10
Floor type:				
Deep litter	80	50.0 (40)[1]	35.0 (28)	15.0 (12)
Raised slats	19	52.6 (10)	42.1 (8)	1.0 (1)
Caging	2	0 (0)	100 (2)	0 (0)
Chicken type:				
Broilers	38	52.6 (20)	29.0 (11)	18.4 (7)
Pullet (grow-lay)	63	47.6 (30)	42.9 (27)	9.5 (6)
Total	101	50	38	13
Percentage of total	-	49.5	37.6	12.9

Notes: 1.Number of observation per cell. ***Source***: Poné (1993)

3.2.2.1. Level of farm equipment

Forty five percent of the farms were fenced or protected from outsiders. The level of mechanization was very low. Out of 106 farms, 23% used a farm transport vehicle and 9.4% had quarantine facilities. Battery cage units were found in one farm while 3 farms had feed mill facilities. One farm each had a small hatchery unit, a processing plant unit, a freezing/cooling room, a feed bin, and automatic feeders (Table 16).

Most production units lacked diagnostic laboratories and egg grading machines. Ten farms had stand-by generators, 32 had water pumps, 17 used automatic drinker systems, 31 and 11 farms possessed electrical and gas brooding equipments, respectively. 18 farms hired someone to debeak their chickens with an electric debeaker, 15 and 12 farms had reception and sale offices, respectively. Four farms had manual disinfectant pump/sprayer (Table 16).

3.2.2.2. Construction materials

Sun-dried mud blocks (51 %) and raffia bamboo (47 %) were the most popular materials used on the wall of poultry houses (Poné, 1993). Few walls of the deep litter system were plastered half way inside. Epo (1983) reported that 58.6 % of all poultry houses floors were cemented while 41.4 % were not, but Poné (1993) reported that over 70 % of the deep litter floor were cemented.

Eucalyptus poles (68.6 %) and sawed wood (65.7 %) were used for roof frames. Corrugated zinc sheets (93.1 %) and transparent zinc sheets (10.8 %) were common roof covers. Dried grass/hay (Hyparrhenia spp. and Imperata cylindrica) and wood shavings were the most important floor litter materials and represented 34.9 %, 29.7 %, and 24.4 % of all cases, respectively (Poné, 1993).

Table 16. Level of surveyed farm equipment

Type of equipment	Frequency (number of farms)	Percentage (out of 106 farms)
Sweeping broom	101	95.3
Manual feeders	100	94.3
Manual drinkers	97	91.5
Spade	89	84.0
Bush lamp brooder	74	69.8
Wheel barrow	67	63.2
Scrubbing hand brushes	65	61.3
Waste disposal procedure	63	59.4
Hover for brooding	59	55.7
Fork	54	50.9
Water pit/wells	54	50.9
Pushing truck/scales/rake	50	47.2
Fencing	48	45.3
Electric brooder	31	29.2
Water tank	28	26.4
Knife for debeaking	27	25.4
Farm transport vehicle	24	22.6
Water pump	22	20.8
Automatic drinkers	17	16.0
Reception office	15	14.2
Sales office	12	11.3
Gas brooder	11	10.4
Quarantine house	10	9.4
Standby generator	10	9.4
Feed mill	3	2.8
Other equipment	2	1.9

Source: Poné (1990)

3.2.2.3. House size

The shape of the buildings was rectangular averaging 93.2 m^2 per house and 255.2 m^2 per farm in size, respectively. Each farm had an average of 3 poultry buildings. Table 17 shows the scale of floor area in poultry houses. 41.7 % of them had floor areas less than 50 m^2. Epo (1983) reported that poultry farms around Yaoundé were sufficiently big in sizes with about 79 % falling between 250 and 500 $m^2$of floor space. However, he pointed out that only about 58 % of the surfaces were occupied by chickens. Reasons for these non utilization of space attributed to lack of day-old-chicks when needed, broiler marketing difficulties, inadequate funds, and longer quarantine periods.

Table 17. Frequency distribution of poultry house floor area (m^2).

Classes (m^2)	Number of houses	Percentage
<50	105	41.7
50-99	54	21.4
100-149	41	16.3
150-199	31	12.3
200-249	10	4.0
250-300	5	2.0
>300	6	2.4
Total	252	100.0

Source: Poné (1993)

3.2.2.4. Routine management practices

Farm morning activities included flock observation, feed and watering, carcass removal, cleaning and egg collection. In the afternoon, flock observation, feeding/watering and egg collection were routinely achieved. Culling, herbage supply, and other activities were practised in few farms (Poné, 1990). The percentage of farmers who carried out these activities daily were: flock observation (27.5%), feeding and watering (26.7%), egg collection (16.4%), and to a lesser extent carcass removal (12.2%) and cleaning of appliances (7.7%) (Poné, 1990).

3.2.2.4.1. Brooding management

Partial house brooding was practised by 91% of the farmers. Kerosene fuelled bush lamps (KFBL) and electricity were used as fuel source during brooding by 71% and 29% of the farms, respectively. Charcoal or wood burning was used to complement kerosene lantern or electricity (Table 18). No farm was found using radiant gas brooding technique although some possessed the equipment. Hovers were used in 61% of cases at a height of 0.83 m. This technique was similar for all house flooring type (Poné, 1993). Epo (1993) reported that 73% of the farms used KFBL as energy for brooding chicks.

Table 18. Brooding management according to floor type and energy sources.

Practice	Count	(%)	House floor type	
			Deep litter	Raised bamboo
Brooding:				
Partial	21	91.3	90.0 (18)[1]	100.0 (3)
Whole house	2	8.7	10.0 (2)	0.0 (0)
Energy source:				
Kerosene	17	70.8	71.4 (15)	66.7 (2)
Electricity	7	29.2	28.6 (6)	33.3 (1)
Wood or charcoal	1	4.2	4.8 (1)	0 (0)

Notes: 1. Number of observation for each cell unit. *Source*: Poné (1993)

Two-thirds of broiler farmers brooded chicks for three weeks and one-third did so for a period of four weeks. Pullet chicks and chicks from mixed operations were brooded for 4 weeks in 70% and 50% of the farms, respectively (Poné, 1990).

3.2.2.4.2. Debeaking practises

Debeaking was not done on broiler farms, however, 80% and 90% of the layer and mixed operations debeaked their chickens, respectively. 40% of farmers practising debeaking did so for the second time when pullets were 20 weeks old. The first debeaking was done at 12 weeks of pullets age (Table 19).

3.2.2.4.3. Record keeping

Out of 106 farmers interviewed, 81 %, 70 %, 69 %, 68 %, and 64 % of them kept records on mortalities, vaccination, feed intake/purchase, sales and expenses, and culled out birds, respectively. Half of these farmers kept no written records but remembered facts vividly. Lighting time table, temperature, and body weight were recorded only by 14, 7, and 4 farmers. Out of 69 farms keeping egg type flocks, 48 (70 %) kept records on egg production. Humidity was not measured at all in all farms surveyed (Poné, 1990).

Table 19. Frequency of farms practising debeaking, expressed as percentages of counts.

Farm type	Count	First debeaking Birds age (weeks)	Second debeaking (%)	Birds age (weeks)
Layer	47	11.4	38.3	19.6
Mixed (boiler & layer)	9	13.4	55.6	20.4
Average:		11.7	41	19.7

Source: Poné (1990)

3.2.3. Feed and feeding management

3.2.3.1. Feedstuffs and feed sources

(a) Feedstuffs. Table 20 shows the major feedstuffs produced in the MHAZ compared to national totals. Apparently, the Zone is not self-sufficient in cereal and tubers, but sufficient in bananas and plantains production and has a good potential for pasture production. Crop in excess of or not fit for human consumption is used for animal feed. Most often there is open competition in the market between buyers of feedstuffs for animal feed and the buyers for human feed. Table 20 also shows the extraction rates for estimation from total crop produced of feedstuff quantities for animal feeds. Maize, the principal energy source for chicken feed is seasonal and in short supply (Fomunyam *et al.*, 1990). It is also of low lysine content. The main protein source is cotton seed meal produced from the cottonseed oil mills of Northern Cameroon. Palm kernel cake and soya bean meal (mostly imported) is also used. In an analysis of crop by-products for animal feed in the North West Province, Fomunyam *et al.* (1990) found that about 52,000 tons of these were available yearly. Matching available nutrients to livestock population and needs, the authors reported a deficit in both total dry matter and crude protein (Table 21).

Table 20. Production of major foods and agro-processing by-products in MHAZ (tons).

Crop & by-products	North West Province	West Provinces	MHAZ total	MHAZ as % of national
Maize	10,623	6,998	17,621	68.3
Banana	11,071	15,468	26,539	56.0
Plantains	25,340	19,321	44,661	73.4
Cocoyams	20,213	5,470	25,683	81.5
Cassava	62,348	53,024	115,372	59.3
Sweet potato	24,151	48,200	72,351	25.1
Yams	nd	nd	nd	nd
Irish potato	1,038	639	1,677	77.8
Beans	nd	nd	nd	nd
Groundnut cake	8,051	7,400	15,451	33.0
Rice bran	356	774	1,130	69.5
Palm oil sludge	3,114	1,841	4,955	45.1
Sugar cane molasses	2,132	3,116	5,248	nd
Palm kernel meal	nd	4,618	nd	nd

Notes: ND: No data. ***Source***: MINAGRI/DPAO/SPESAO, Annual reports, West/North West Provinces (1989/90). Fomunyam *et al.* (1990).

Table 21. Balance sheet of livestock nutrient needs from crop by-product feed in the North West Province (*1000 tons).

Descriptions	Dry matter	Crude protein
Livestock nutrients requirements	1,893.0	149.5
Nutrients available from food and cash crop by-products	226.9	40.3
Nutrient deficit	1 666.1	109.2
Self-sufficiency rate (%)[1]	12.0	26.9

Notes: 1. Obtained as ratio of available by-products to animal nutrient requirements. ***Source***: Fomunyam *et al.* (1990).

(b) Feed mills and feed dealers. Three feed manufacturers and suppliers (SPC, SAC, NUTRICAM) produce most of the livestock feed. 53,000 tons of poultry feed is sold annually. Feed is also sold by smaller commercial companies and by owners of private mills. A dozen farmers own small mills for private use and occasionally sell feed in excess of use upon demand for which data was not readily available.

Most mills operate at 30-45% capacity (Table 22). The types of feed produced and sold as mash are for broiler starters and finishers, pullet starters, growers, and layers. Protein premixes at 5%, 10%, 20%, and 40% concentrations do exist both for broilers and layers. Farmers need only add an energy source, usually maize as specified by manufacturers, to obtain a complete mash for the type and class of chickens. This sometimes leaves room for adulteration.

(c) Feeding systems. Djoukam and Téguia (1991) reported that 95% of poultry farmers used commercial feed while 5% used home made feed. They also found that 77% of home made feed users kept more than 2500 birds while 15% of them kept less than 500 birds (Table 23). This last category of farmers might not be well armed to prepare balanced chicken diets. Feed is fed free choice in wooden or plastic feeders while water is given in plastic containers. Both feed and water are given once a day.

Table 22. Trends in annual animal feed production by local feed mills (tons).

	1988/89	1989/90	1990/91	Feedmill Capacity
SPC (AGROCAM)	19,540	15,654	15,600	30,000
SADE	1,747	425	nd	6,000
EPA (AZANGUE)	9,000	10,000	10,400	12,000
NUTRICAM (ADER)	2,400	2,400	6,000	14,400
ONDAPB	3,485	2,411	1,544	28,000
CACIR Yaounde	nd	nd	nd	3,000
MONASTERY-Mbwengwi	nd	nd	1,300	4,500
RTC Mfonta	nd	nd	900	1,400
Lapinière	nd	nd	nd	19,000
IRZV	287	298	273	6,000
Other feed mills	14,000	20,000	20,000	56,000
Totals	50,459	51,188	60,017	181,300

Notes: nd :no data. ***Sources***: IRZV Mankon (1988);Crouail and Duault (1991); Batimba and Mewoand (1992).

Table 23. Users of home made feed grouped according to flock sizes.

Farm flock size (number of birds)	Number of farms	Percentages
<500	2	15.4
501-1000	0	0
1001-2500	1	7.7
>2500	10	76.9
Total	13	100

Source: Djoukam and Téguia, 1991

(d) Chemical composition and feed standards. Tables 24 and 25 provide results of preliminary analyses of selected feedstuffs. The energy values were not be determined because of a burnt out galvanometer of the bomb calorimeter. Similarly, the amino acid analyser is temporary out of order. Analyses are carried out according to A.O.A.C. (1975). Routine analysis of these feedstuffs and feeds both at preparation and storage is the basis for the establishment of feedstuffs and feed standards at National Biochemistry Laboratory (NBL) Mankon.

Most feed manufacturers have no quality control facilities. No strict control on the quality of feedstuffs and feed is carried. There are no dates of manufacture or of expiration of commercially sold feed. Labels only carry minimum information. Size, shape, colour, and writings on the labels is at the discretion of feed manufacturers.

Table 24. Proximate composition (%) of common poultry feeds

Feedstuffs	Dry matter	Crude protein	Crude fat	Crude fibre	Ash	PDM
Maize	89.4	8.2	4.7	2.7	1.3	
Rice bran	89.9	6.4	4.7	19.4	15.4	
Wheat bran	91.6	16.7	6.6	8.6	4.6	
Brewers' grains	90.4	27.9	7.7	15.4	3.5	
Palm cake	90.8	12.7	18.9	21.1	3.4	
Peanut cake	91.9	41.8	12.0	7.6	5.0	
Cotton seed cake, pelleted	90.5	33.4	3.3	8.6	7.3	
Cotton seed cake, unpelleted	94.1	52.5	6.7	5.1	7.2	
Fishmeal	90.5	61.3	4.4	0.7	22.1	
Blood meal	92.4	81.7	0.2	-	4.4	
Oyster shells	99.8	0	0.0	0.0	99.4	
Sweet potato tuber, T1B1	92.5	1.2	0.3	nd	4.0	28.1
Sweet potato tuber, T1B2	92.0	1.3	0.2	nd	3.0	25.2
Sweet potato tuber, 1112	97.5	1.4	0.4	nd	3.5	29.4
Cassava root, 79152	90.0	1.5	0.5	nd	3.0	36.8
Cassava root, 7621	92.5	1.5	trace	nd	3.5	45.8
Cassava root, 79307/8	91.4	1.5	trace	nd	4.0	33.9
Cassava root, local red	92.3	1.3	trace	nd	4.0	42.5
Cassava root, local white	95.7	1.4	trace	nd	5.0	40.6

Notes: PDM - Partial dry matter of roots (as a percentage of fresh root and tuber). nd = not determined. ***Source***: NBL Mankon (1994).

Table 25. Chemical composition of selected livestock feed.

Commercial feeds	Dry matter	Ash	Organic matter	Crude protein	Crude fat	Crude fibre	NFE
Poultry starter mash	91.2	12.9	78.3	18.0	7.6	5.5	47.2
Poultry grower mash	91.2	9.2	82.0	13.0	5.6	5.9	57.5
Poultry layer mash	91.0	9.2	81.7	16.8	7.3	5.4	52.3
Pig creep mash	91.6	6.3	85.2	21.2	8.2	4.4	51.5
Pig grower mash	91.6	7.6	84.0	17.8	6.6	5.9	53.7
Rabbit all mash	90.3	8.7	83.6	19.3	7.0	7.9	49.4
Goat feed	91.6	6.4	85.2	17.8	5.0	8.3	54.1

Source: NBL (1994).

(e) Feedstuffs and feed marketing. Maize which constitutes 50-65 % of chicken feed remains in short supply and the seasonality of its production often compels feed manufacturers to resort to importation. Tables 26 and 27 give export and production data for some commonly used feedstuffs.

Imported feedstuffs are mostly protein and vitamin and mineral premixes. On average, 10,000 tons of soybean meal worth 1.6 million FCFA and 720 tons of premixes worth 144 millions FCFA are imported annually (Crouail and Duault, 1991). In 1990, Cameroon spent 400 million FCFA of foreign exchange earnings for import of calcium carbonate needed as calcium supplement (Duplaix, 1990).

It is rather difficult to understand why livestock feed preparations use imported soybean meal, given there are local producers of this meal. Furthermore, substitutes have been proposed by IRZV researchers. For instance, cotton seed cake can be used efficiently at levels up to 30% in the diets for broiler and laying chickens (Poné et al., 1986 and 1987) and up to 7.5% in breeders diets (Dongmo *et al.*, 1987). Yet, about 20 tons of cotton seed cake were exported in 1989. Poné and Dongmo (1990) reported that at 4% dietary level, sun-dried leucaena leaf meal was acceptable egg yolk colourant. Recently, Téguia et al. (1992) reported that at 3% dietary levels, chicken egg shells, snail shells and oyster shells were comparable to imported calcium carbonate for egg production and egg quality of laying hens.

Current market prices for poultry feedstuffs and poultry rations as per classes of chickens are provided in Table 28. Because of the devaluation of the FCFA, this sector is quite fluid and prices are continuously on the rise.

Table 26. Trends in imports and exports of poultry feedstuffs in Cameroon (tons).

Year	**1988**	**1989**	**1990**
***Imports*:**			
Maize	4,368	10,910	9,795
Soyabean meal	418	1,049	3,806
Premixes	2,930	5,008	5,975
***Exports*:**			
Palm kernel cake	2,714	4,353	nd
Cotton seed cake	nd	19,699	nd
Various cereal brans	5,778	1,228	nd

Notes: nd:-no data. ***Source***: Syndicat des Acconiers (1990).

Table 27. Meat processing by-products production and prices at SODEPA (tons).

By-products	**FCFA/kg**	**1989/90**			**1990/91**		
		Douala	**Yaounde**	**Total**	**Douala**	**Yaounde**	**Total**
Blood meal	230	7,235	49,073	56,310	nd	43,043	43,043
Meat and bone meal	230	2,090	3,740	5,830	6,600	2,331	8,930
'Cornillons'	100	11,400	7,173	18,570	nd	49	49
Fishmeal	250	4,096	274	4,370	10,090	360	10,450

Notes: nd - no data. ***Source***: SODEPA activity report.

Table 28. Prices of feedstuffs in Cameroon before and after currency devaluation in 1991 (FCFA/kg).

Feedstuffs	Before devaluation	After devaluation
Maize	70-100	140-160
Sweet potato tuber (DM)	40-50	75-80
Cassava root (DM)	30-40	60-75
Soya bean meal	160-200	300
Cotton seed cake	60-80	120
Palm kernel cake	35	55
Wheat bran	45	50
Bone meal	30-35	55-60
Oyster sea shells	35-50	70-80
Salt	66	122
Fish meal	600	800
Palm oil sludge	20	50
Rice bran	35	60
Palm oil	120	300
Blood meal	300	550
Vitamin mineral premix	14,000	26,000
Commercial chicken feeds:		
Broiler starter	136	180
Broiler finisher	132	160
Layer starter chick	127	165
Layer grower chick	115	145
Laying hen	124	160

Source: Local markets in Bamenda.

3.2.4. Health and health management

3.2.4.1 Observed poultry diseases

Most tropical viral, bacterial and parasitic diseases are enzootic in the area. Epo (1983) reported that coccidiosis (32.9 %), chronic respiratory disease (20 %), and diarrhoea (12.9 %) were the principal disease problems/symptoms encountered by poultry farmers. The same author pointed out that 56 % of the farmers had the tendency to diagnose and prescribe medicine for their chickens without prior consultation of a specialist. Furthermore, farmers tended to adulterate feed inevitably leading to nutritional imbalances and consequent health problems. Disposal of dead carcasses on the farm remains a critical problem. Farmers suggested that an analysis and revamping of the drug delivery system be carried out.

3.2.4.2. Health management

(a) Use of disinfectant foot bath. One-fifth of surveyed poultry houses had a disinfectant foot bath at their entrance as a disease preventive measure. Of these, houses with layers (27 %) were more protected than those with broilers (18 %) (Poné, 1993).

(b) Deworming practises. Only 19 % of broiler farms were reported (Poné, 1990) to practise de-worming as compared with 78 % and 70 % of layer and mixed operations, respectively. As shown in Table 29, de-worming was done only once for broilers and at least twice in laying flocks. Broilers were de-wormed by 5 weeks of age. Pullets were first de-wormed at 13 weeks of age. 41 % of laying flocks already de-wormed at 13 weeks old were de-wormed the second time just before point-of-lay (19 weeks old).

(c) Quarantine period between two crops of chickens. The quarantine period between two consecutive flocks/crops in the same building varied from a minimum of two weeks to a maximum of 26 weeks. Reasons for these differences were lack of day-old-chicks, poor marketing, frequent disease incidence, lack of finances, and above all poor management planning (Poné, 1990).

Table 29. Frequency distribution of farms practising de-worming according to farm type, expressed as percentages of counts.

Farm type	Number of farms	First de-worming Birds age (weeks)	Second de-worming (%)	Second de-worming Birds age (weeks)
Broiler	6	5.3	0.0	
Layer	46	13.0	43.5	18.8
Mixed (broiler & layer)	7	13.5	28.6	22.0
Average:		12.2	40.7	19.0

Source: Poné (1990)

3.2.5. Meat and egg technology

3.2.5.1. Processing

Meat processing is not well organized in the poultry industry in Cameroon. Some work on frozen, dehydrated, smoked chickens as well as on carcass characterization have been carried at IRZV (Imélé, 1989, unpublished data; Poné *et al.*, 1985), and some private companies (Table 30).

Another type of processing occurs through mobile cafeteria. Here eggs are boiled and sold at 75-100 FCFA a piece with hot pepper sauce. When fried with oil, an egg sells for 100-150 FCFA including other spices and charges for services rendered.

Table 30. Carcass yield of broiler chickens produced in Cameroon.

Characteristics	Broilers[1]	%	Broilers[2]	%
Birds age (weeks)	8	-	12	
Liveweight (g)	1,500	100	2090	100
Dressed weight (g)	1,200	80	1722	82.4
Ready to cook weight (g)	975	65	1398	66.9
Gizzard weight (g)	30	2	37.6	1.8
Leg weight (g)	60	4	nd	nd
Liver weight (g)	30	2	29.3	1.4
Head and neck weight (g)	7.5	0.5	nd	nd
Abdominal fat pad weight (g)	nd	nd	8.6	0.4
Heart weight (g)	nd	nd	117	5.6

Notes: nd - no data. 1. (STV) Société de Transformation de Volailles, Douala, 1990. 2. Poné *et al.* (1985).

3.2.5.2. Quality standards and control

Laws do exist but are not well controlled due to unorganized markets. Egg quality (Haugh units) which is high at farm gate (82.6 - 90.4; Poné, 1993) will quickly deteriorate by the time consumers buy them due to poor storage facilities during transportation from farm to market. Eggs are stored at room temperature, and the further they travel from farms, the more unstable the egg contents become, due to poor road infrastructure, unadapted transportation containers, and environmental stress (heat, high relative humidity, dust).

3.2.6. Socio-economics factors

3.2.6.1. Socio-cultural activities

3.2.6.1.1. Farmer's goals

Table 31 shows that for most broiler farmers poultry was kept essentially for manure (37.7 %) and as a source of income (22.1 %). Family food had the same ranking, as employment needs (13 %). Keeping broilers as a hobby was contemplated by 13% of respondents. The use of farm for research and/or exhibits was reported in one case only.

The major reasons for keeping laying birds were as a source of income (32 %), the use of manure (31.4 %), as a job (18 %), hobby (7 %), and as family food (5.8 %). Research/teaching/demonstration as reason for keeping layers was carried out by 4.5 % of farmers. In mixed farming operations, financial gains (29.6 %), manure (25.9 %), hobby (22.2 %), employment (14.8 %), and research/exhibition (3.7 %) or food for the family (3.7 %) were recorded. Although farmers kept chickens, Table 32 shows that in 44.8 % of cases, crop farming was the major occupation of interviewed farmers. Only 2 % of them were engaged in the poultry business, principally those have been to school. Civil servants represented 21 %, skilled workers (mason, carpenters, craftsmen) amounted to 15 %. Petit traders (11.4 %), religious staff (2.9 %) and traditional chiefs (3 %) were the occupations of the other farmers.

Table 31. Farmer's objectives for keeping chickens according to farm type, expressed as percentages of counts.

Farm type	Number of farmers	Producer objectives in rearing chickens					
		Income	Hobby	Research and exhibition	Use of manure	Food	Job
Broiler	77	22.1	13.0	1.3	37.7	13.0	13.0
Layer	156	32.0	7.0	4.5	31.4	5.8	18.0
Mixed (broiler & layer)	27	29.6	22.2	3.7	25.9	3.7	14.8
Total:	260	28.9	10.4	3.5	32.7	7.7	16.2

Source: Poné (1990)

3.2.6.1.2. Sex and age of farmers

Men represented 75 % of the surveyed population. More than half of the broiler farms were handled by women while men managed 89 % of the layer enterprises (Table 33). This trend was also reported by Djoukam and Téguia (1990).

Table 32. Level of education and major occupation of interviewed poultry farmers expressed as percentages of total counts.

Level of education	Number of farmers	Civil servant	Crop farmer	Religious staff	Petit-traders	Retired staff	Skilled worker	Local chief	Poultry farmer
None	12	0	66.7	0	16.7	0	8.3	8.3	0
Primary	52	1.9	55.8	0	13.5	0	25.0	1.9	1.9
Secondary and higher	36	33.3	25.0	8.3	8.3	13.9	5.6	2.8	2.8
Vocational	5	60.0	20.0	0	0	20.0	0	0	0
Total:	105	15.2	44.8	2.9	11.4	5.7	15.2	2.9	.9

Younger (<20 years old) farmers represented only 1.0 % of the surveyed population. The active age groups 20 to 39 years old represented 44 % of respondents. However, farmers below 40 years old represented 56 %, 41 % and 40 % for broiler, layer and mixed operations, respectively (Table 33). 86 % of the respondents were 30 years and above with 67 % of them between 30 and 50 years old.

A trend towards aged farming population could be associated although not exclusively to land acquisition/inheritance problems. 54 % of the land used for crop and livestock production in the North West Province (Momo division) were reported to be inherited while only 13 % were purchased (LSRP-Bambui, 1989).

Table 33. Age and sex of chicken producers (as percentages of counts) according to farm type.

Farm type	Count	Sex		Count	Age (years)				
		Male	Female		<20	20-29	30-39	40-49	>50
Broiler	31	48.4	51.6	32	0.0	28.1	28.1	34.4	9.4
Layer	55	89.1	10.9	54	1.9	5.6	33.3	24.1	35.1
Mixed (broiler & layer)	10	80.0	20.0	10	0	10.0	30.0	50.0	10.0
Total	96	75.0	25.0	96	1.0	13.1	31.3	31.3	23.3

Source: Poné (1990).

3.2.6.1.3. Level of eduction of poultry producers.
The surveyed group had a literacy (reading and writing English or french) of 88 %. Illiteracy rates averaged 9 % and 17 % in broiler and layer operations, respectively (Table 34). A further analysis of the data showed that those who never attended school fell within the ages of 40 and 50 years.

3.2.6.1.4. Farm age and registration status
As shown in Table 35, 76 % of the farms were ten (10) years old. Twice as many broiler than layer farms (19 % vs. 9 %) were below one year old. Broiler operations were younger with 97 % being less than 11 years old compared to 63 % for layer operations. 88 % of the farms were not in the government extension office register and might be a serious concern for the organization of farmers.

3.2.6.1.5. Farm labour use

Table 36 shows that 4 % of the farms used hired workers only. One fifth of the farms employed paid poultry attendants and 79 % of the farms used exclusively family work force. In Table 37, average poultry paid worker earned 19,000 FCFA a month. This is close to the minimum wage of 21,000 FCFA paid to unskilled labourers. Higher wages of about 29,000 FCFA were paid to workers on laying birds farms, probably due to the intense nature of work involved and the substantial flock size of 410 birds/farm compared to 294 birds per broiler farm. However, salary varied from 10,000 FCFA to 40,000 FCFA. The highest reported wage was that for technicians.

Table 34. Percentage formal educational level of farmers according to farm type.

Farm type	No schooling	Primary school	Secondary school	High school	Technical training	College/ University
Broiler	9.4	46.9	12.5	12.5	6.2	12.5
Layer	16.7	53.7	14.8	3.7	0	11.1
Mixed (broiler & layer)	0	45.5	27.2	9.[illegible]	18.2	0.0
Total	11.8	50.0	15.7	7.8	4.9	9.8

Source:Poné (1990).

Table 35. Percentage poultry farms age and registration status according to farm type.

Farm	Age (years)				Registration status	
type	<1	1-3	4-10	>10	Yes	No
Broiler	18.8	37.5	40.6	3.1	3.1	86.9
Layer	8.8	7.5	36.8	36.8	12.5	87.5
Mixed (broiler & layer)	20.0	30.0	30.0	20.0	30.0	70.0
Total	12.6	26.2	36.9	24.3	11.8	88.2

Source: Poné (1990).

3.2.6.2. Economic activities

3.2.6.2.1. Sources of financing

Djoukam and Téguia (1991) reported that over 85 % of funding for intensive poultry farming was from private funds (family income or loan from village/family groups ("Djangui"). This trend was consistent whether the activity was a principal or secondary job, or male- or female-run (Table 38).

Table 36. Labour characteristics in poultry farms according to farm type.

Farm type	Number of farms	Hired only	Spouse & children	Owner only	Owner and family	Owner and hired	Owner, family and hired
Broiler	32	3.1	0	12.5	68.8	12.5	3.1
Layers	59	5.1	3.4	8.5	69.4	5.1	8.5
Mixed (broiler & layer)	10	0	0	0	60.0	10.0	30.0
Total	101	4.0	2.0	8.9	68.3	7.9	8.9

Source: Poné (1990).

Table 37. Average monthly payment (x 1000 CFA francs) for hired poultry attendants in poultry farms according to farm type.

Farm type	Count	Wage	Range
Broiler	6	15.8	10-30
Layers	1	29.3	10-40
Mixed (broiler & layer)	4	13.0	10-20
Total	21	19.1	10-40

Source: Poné (1990).

3.2.6.2.2. Marketing

Most broilers are sold life and unweighed. However, data gathered showed life broilers weighing from 1.5 kg to 1.8 kg selling at 1500 to 1900 FCFA (1000 FCFA/kg live weight). Eggs are not graded and sold from 800 to 1500 FCFA per 30 eggs. Spent hens are sold during high demand periods at 1500 to 1800 FCFA per head, or 1000 FCFA/kg live weight. Maintenance cost due to piecemeal sales of broilers is 30 FCFA per bird per day after 8 weeks of production. This cost could be minimized provided studies on chicken meat technology are intensified.

Presently, small scale producers carry 5 to 30 broiler chickens in baskets to village markets weekly. To clear a flock of 500 birds it takes about 2 to 6 weeks. In an attempt to reduce these costs or extra charges farmers start sales at 6 weeks of birds age, when bigger birds weigh 1.2 to 1.4 kg. Culls are used for home consumption or sold at discount rates.

Table 38. Source of funding of intensive poultry operations and their relative importance (%) for farmers keeping poultry.

Sources of funding	Relative importance			
	Principal job	Secondary job	Female-run activity	Overall study
Personal funds only	31.2	42.5	45.5	41.5
Personal funding and "Djangui"	43.8	44.8	42.4	44.0
Personal funds and "Farmer's bank" like FONADER	12.5	9.1	9.	10.0
Personal funds and commercial banks	12.5	3.6	3.0	4.5

Source: Adapted from Djoukam and Téguia (1991).

Table 39. Places of sale for poultry products.

Places	Number of farmers	Proportion (%)
Farm-gate	10	13.9
Middle persons	27	37.5
Restaurants/shops/bakeries	18	25.0
Butchers	2	2.8
Market	15	20.8
Total	72	100

Source: Epo (1983).

Epo (1983) reported that most of the poultry products sales (37.5 %) were done by middle-persons (Table 39). Apparently, these economic intermediaries were thought to make most of the profits. However, recent evidence suggest that because of traffic frauds and also slow delivery services, those agents do not get it all. Consumers are the ones paying for extra charges incurred. Eggs bought at 40 FCFA a piece at farm gate sell at 45-55 FCFA each in urban markets.

(a) Market prices and type of products. Tables 40 shows prices of poultry and other meat sold in Bamenda. Locally produced day-old-chicks and hatchable eggs are sold at prices given in Table 41. Retailer prices are above farm gate prices by about 100-150 FCFA for one broiler and 5-10 FCFA for an egg (Table 42).

(b) Priority uses of farm revenue. In 50 % of the answers (Table 43), revenue was being re-invested into the poultry business. 42 % of respondents used money for family living, while investment in another business or other activities was listed by 5.6 % and 2.8 % of the respondents, respectively. This trend was consistent with farm types.

Table 40. Market prices FCFA/kg (carcass weight) of various meat sold at Bamenda/North West Province - Cameroon, before and six months after devaluation of FCFA.

Meat type	Before devaluation	After devaluation
Chicken	800	1,250
Pork	800	1,000
Beef	600	1,000
Rabbit	1,000	1,000
Egg (one)	40	50
Mutton	1,000	1,200
Goat	1,000	1,200
Fish:		
Mackerel	400	550
Barre	450	750

Table 41. Current market prices (FCFA) of day-old-chicks and hatchable eggs.

Institutions	Broiler		Layer		Breeds
	chicks	eggs	chicks	eggs	
ONDAPB-Kounden	340	nd	490	nd	Arco, Hybro
SPC/AGROCAM	350	180	640	nd	Lohmann
EPA	325	nd	700	nd	Arnak, Indian river
IRZV	250	50	500	50	Lohmann and crosses
SABEL	300	nd	nd	nd	nd
Monastery-Mbengwi	nd	nd	nd	100	Rhode Island Red
WAN Poultry-Bamenda	nd	nd	250	nd	Crosses

Note: nd - no data

Table 42. Farm-gate and market prices of poultry products in selected towns in March 1994.

Type of products	Yaounde		Douala		Bafoussam		Bamenda	
	Farm gate	Market	Farm gate	Market	Farm gate	Market	Farm gate	Market
Broiler chicken (FCFA/kg)	900	1,050	870	1,000	800	950	950	1,000
Spent hens (FCFA/kg)	700	,000	600	800	500	600	700	900
Table eggs (FCFA/egg)	38	50	35	40	30	35	35	41

(c) Cost-effectiveness of poultry farms. Vancoppenoble (1991) suggested that egg-type enterprise was uneconomical with a flock size below 500 hens/pullets while broiler operations were profitable with a flock of 500 chicks. IRZV (1990) showed that small scale intensive poultry units are profitable at 100 hens operation or 100 broilers operation after two, or one and a half years.

Broiler operations are more profitable than layer operations because of three factors: low investment cost on housing, day-old-chicks, quick turn over rate (4.5 times a year for broiler and only 0.7 times for layer). However, small scale broiler farmers tend to loose much of the profit and even part of their capital when marketing is not immediate. The presence of organized production and marketing systems will certainly make the business more cost effective. Table 44 shows estimated production costs before and after devaluation of the CFA francs. The key question is, can the poultry farmer survive?

Table 43. Priority uses of farm revenue according to farm type, in percentages of counts.

Farm type	Count	Use of farm revenue: Family living	Re-invest into same business	Use in another business	Others
Broiler	49	38.8	57.1	4.1	0
Layer	110	43.6	47.3	6.4	2.7
Mixed (broiler & layer)	21	42.9	42.9	4.7	9.5
Total	180	42.2	49.4	5.6	2.8

Source: Poné (1990)

(d) Sustainability of production. Farmers encountered some form of setbacks upon opening their operations. This happened when the farm activities were interrupted for at least once during the life span of the enterprise. Two third (67 %) of those farms which were closed at least once did so within the period of four years (Table 45). 36 % of farmers experienced such failure due mostly to inadequate funds and disease outbreaks. Marketing difficulties and lack of day-old-chicks contributed to setbacks for 11 % and 7 % of cases, respectively. Other reasons (11 % of all cases) were listed as quarantine measures, transition to build a separate poultry house out of living quarters, fire disaster, or investment into another business (Table 46).

Table 44. Distribution of production cost (FCFA) items for broiler operations before and six months after FCFA devaluation.

Items	After devaluation FCFA	After devaluation % cost items	Before devaluation FCFA	% cost items[1]	FCFA	% cost items[2]
Number of chicks	2,000		2,000		8 000	
Mortality rate (%)	3.5	-	3.5	-	10.81	
Day-old-chicks	25.0	25.1	250	26.2	247	25.2
Feed & water	810	62.6	560	58.6	647	66.07
Medication	32	2.5	30	3.1	43	4.4
Sanitation	16	1.2	10	1.1	28	2.8
Labour	30	2.3	30	3.1	nd	nd
Brooding & energy	10	1.0[a]	10	1.1	7	0.73[b]
Housing depreciation	40	3.0	40	4.2	nd	nd
Other costs	30	2.3	25	2.6	7	0.74
Total	1,293	100	955	100	979	100
Liveweight price (FCFA/kg)	808	-	560	-	612	

Notes: nd: not determined. Source: 1. Poné (1992) in the MHAZ; 2. Batimba and Mewoand (1992) at Douala-Cameroon; a. Kerosene fuelled bush lamp; b. Stove using wood shavings and fire wood.

Inadequate funds (42.9 %) and disease outbreaks (28.6 %) ranked highest in broiler operations while the opposite was noticed in layer operations which had 47.8 % and 21.7 % of the cases, respectively. Marketing was a problem for broilers than for layer operations (14.3 % vs. 8.7 %). Inadequate funds contributed to about 50 % of drop out rates (Table 46). Bankruptcy is usually the results of many factors e.g. disease outbreaks, high mortalities and poor cash flow system. The fact that 36 % of the farms have been out of production at least once calls for further understanding of this situation.

Table 45. Time elapsed from creation to first shutdown of poultry farms, expressed as percentages of counts.

Farm type	Number of farms	Years in activity until shutdown occurred 1	2	3	4	>4
Broiler	11	0	27.3	18.1	27.3	27.3
Layer	22	13.6	18.2	18.2	9.1	40.9
Mixed (broiler & layer)	2	0	50.0	50.0	0	0
Total	35	18.5	23.1	18.0	2.8	33.3

Source: Adapted from Poné (1990).

Table 46. Proportion of poultry farms having interrupted their activities at least once and reasons attributed to that, expressed as percentages of counts.

Farm type	Interrupted at least once		Reasons for shutting down					
	Number of farms	Yes	Number of farms	Inadequate funds	Disease outbreak	Marketing	Lack of day -old-chicks	Other reasons
Broiler	32	34.4	14	42.9	28.6	14.3	0	14.3
Layer	55	36.4	23	21.7	47.8	8.7	8.7	13.
Mixed (broiler & layer)	10	20.0	2	100	0	0	0	
Dropped out farmers	3	100	6	50.0	16.7	16.7	16.7	
Total	100	36.0	45	35.5	35.6	11	6.7	11.

Source: Poné (1990)

3.2.7. Environmental constraints

It was assumed that rearing chickens in town or around city dwellings creates conflicts or complaints from neighbours. This was not the case as 96 % of the respondents rejected the hypothesis. On the other hand, 60 % of the poultry farms faced environmental constraints (Table 47) associated with one or combinations of problems such as cats eating chicks (25.6 %), theft (24.2 %), cat and theft cases combined (22.6 %), stray animals (9.7 %), theft and stray animals combined (9.7 %), cats and stray animals combined (6.4 %), and cats, theft, and stray animals combined (1.6 %).

3.2.7. The future of the modern sector

This sector like the traditional sector has developed very well without government interference. What needs to be done is for farmers to organize themselves so as to disentangle the bottlenecks in this business namely supply of chicks, feed, drugs, processing and marketing. The development of appropriate poultry ration technology for different groups of producers in accordance with their resources and constraints and objectives, which are related to the other agricultural and employment activities they are engaged in, is crucial to the the development of this sector. The project concept makes a major thrust into this area, which has been hitherto ignored by livestock planners.

Table 47. Environmental constraints reported as problems in surveyed areas.

Constraints	Count	Proportion (%)
(1) Cats eating chicks	16	25.8
(2) Theft cases	15	24.2
(3) Stray animals	6	9.7
(1) & (2)	14	22.6
(1) & (3)	4	6.4
(2) & (3)	6	9.7
(1), (2) & (3)		1.6
Total	62	100

Source: Poné (1990)

4.0. Conclusion

Poultry is the one protein source likely to supply the much needed meat at a cheaper price to satisfy the rapidly growing Cameroon population in general and specifically the urban population as well as revamp the rural economy. The short production cycle of the chicken, low investment and family developed technology and the fact that chicken meat unlike pork has no cultural barrier, makes this animal species worth re-evaluating in the Cameroon context.

A 'chicken policy' is required for efficient chicken production. The main objectives of the policy should be:

(a) ***To ensure adequate day-old-chicks***. Research institutions and the farmers are the principal actors in the development of adapted breeding stock as well as the establishment of guidelines on any imports of breeding stock into the country.

(b) ***To ensure efficient management of inputs***. Farmers should take the lead to organize themselves and the input-output supply of the poultry business needs. Government policy should liberalize all sales and purchases as well as effect measures against traffic fraud. Research results on standards of all goods is necessary.

(c) ***To establish efficient marketing systems***. Farmers should organize their marketing, although government policy on the protection of local production is very necessary. Research must supply information to keep production costs low.

(d) ***To establish an efficient management information system***. All actors in the business should establish an information circulation system for the benefit of all stakeholders as has been done for coffee production. A forum should be established for exchange of ideas at all levels of production.

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Appendix 16.4. Feed samples prepared in Mankon Research Station for use in NRI Phase 2 experiments.

Sample Number	Sample Preparation Date	NRI Phase 2 feeding Trial No/Date	Sample description	First on-station testing date[1]	First on-farm testing date
1.	Feb 1995	1/May 1995	Maize (local)	Mar 1995	Feb 1996
2.	Feb 1995	1/May 1995	Sweet potato TIB1 shreds	Mar 1995	-
3.	Feb 1995	1/May 1995	Sweet potato TIB2 shreds	Mar 1995	-
4.	Feb 1995	1/May 1995	Sweet potato 1112 shreds	Mar 1995	Feb 1996
5.	Feb 1995	1/May 1995	Cassava Red shreds	Mar 1995	-
6.	Feb 1995	1/May 1995	Cassava White (CASWht) shreds	Mar 1995	Feb 1996
7.	Mar 1995	2/Jul 1995	SPTIB1-5%PPS	-	-
8.	Mar 1995	2/Jul 1995	SPTIB1-10%PPS	-	-
9.	Mar 1995		SPTIB1-15%PPS	-	-
10.	Mar 1995	2/Jul 1995	SPTIB1-20%PPS	-	-
11.	Mar 1995	2/Jul 1995	SPTIB1-25%PPS		-
12.	Mar 1995	2/Jul 1995	CASWht-5%PPS	Oct 1995	Feb 1996
13.	Mar 1995	2/Jul 1995	CASWht-10%PPS	Oct 1995	Feb 1996
14.	Mar 1995		CASWht-15%PPS	Oct 1995	Feb 1996
15.	Mar 1995	2/Jul 1995	CASWht-20%PPS	Oct 1995	Feb 1996
16.	Mar 1995	2/Jul 1995	CASWht-25%PPS	Oct 1995	Feb 1996
17.	Mar 1995	3/Jul 1995	SPTIB1-5%WPK	Oct 1995	Feb 1996
18.	Mar 1995	3/Jul 1995	SPTIB1-10%WPK	Oct 1995	Feb 1996
19.	Mar 1995	3/Jul 1995	SPTIB1-15%WPK	Oct 1995	Feb 1996
20.	Mar 1995	3/Jul 1995	SPTIB1-20%WPK	Oct 1995	Feb 1996
21	Mar 1995	3/Jul 1995	SPTIB1-25%WPK	Oct 1995	Feb 1996

(continued next page)

Feed samples prepared in Mankon Research Station for use in NRI Phase 2 experiments.

22.	Jun 1995	-	SPTIB1-5%PKC	-	-
23.	Jun 1995	-	SPTIB1-10%PKC	-	-
24.	Jun 1995	-	SPTIB1-15%PKC	-	-
25.	Jun 1995	-	SPTIB1-20%PKC	-	-
26.	Jun 1995	-	SPTIB1-25%PKC	-	-
27.	Jun 1995	4/Oct 1995	CASWht-5%PKC	-	-
28.	Jun 1995	4/Oct 1995	CASWht-10%PKC	-	-
29.	Jun 1995	-	CASWht-15%PKC	-	-
30.	Jun 1995	4/Oct 1995	CASWht-20%PKC	-	-
31.	Jun 1995	4/Oct 1995	CASWht-25%PKC	-	-
32.	Jun 1995	4/Oct 1995	CASWht-5%WPK	Oct 1995	Feb 1996
33	Jun 1995	4/Oct 1995	CASWht-10%WPK	Oct 1995	Feb 1996
34.	Jun 1995	-	CASWht-15%WPK	Oct 1995	Feb 1996
35.	Jun 1995	4/Oct 1995	CASWht-20%WPK	Oct 1995	Feb 1996
36.	Jun 1995	4/Oct 1995	CASWht-25%WPK	Oct 1995	Feb 1996
37.	Sep 1995	5/Apr 1996	SP1112-fermented 24 hrs	-	-
38.	Sep 1995	5/Apr 1996	SP1112-fermented 48 hrs	Mar 1997	-
39.	Sep 1995	5/Apr 1996	SP1112-fermented 72 hrs	-	-
40.	Sep 1995	5/Apr 1996	CASWht-fermented 24 hrs	-	-
41.	Sep 1995	5/Apr 1996	CASWht-fermented 48 hrs	Mar 1997	-
42.	Sep 1995	5/Apr 1996	CASWht-fermented 72 hrs	NS	NS
43.	Sep 1995	6/Apr 1996	SP1112-25% SPLM	NS	NS
44.	Sep 1995	6/Apr 1996	SP1112-50% SPLM	NS	NS
45.	Sep 1995	6/Apr 1996	CASWht-25% CLM	Mar 1997	-
46.	Sep 1995	6/Apr 1996	CASWht-50% CLM	Mar 1997	-

Note: PPS palm pit sediment, PKC traditionally-processed palm kernel cake; WPK whole palm kernels; SPLM sweet potato leaf and vine meal; CLM cassava leaf meal. - broiler trials were not conducted on these samples. 1. The first time the feed mixture concept was tested in field feeding trials. - NS feed mixture rejected as 'not suitable'. Percentage incorporation rates refer to sun-dried material.

Appendix 16.5. Composition of feed samples from the project field site, on an as received basis (%).

	Dry matter	Moisture	Crude protein	Ether extract	Crude fibre	Ash	Calcium	Phos-phorus	Salt	Lysine	Methionine + cystine	AME (MJ/kg)	Price/kg (FCFA)	Format No
Roots and Tubers:														
Maize - (White)	93.65	6.35	7.64	4.35	1.75	1.19	0.01	0.25	0.01	0.31	0.66	13.98	157	1000
Sweet potato TIB1(SPTIB1)	96.67	3.33	3.98	1.07	2.63	3.06	0.11	0.12	0.02	0.20	0.17	12.03	106	1001
Sweet potato TIB2	93.86	6.14	5.07	0.79	2.58	3.28	0.01	0.11	0.01	0.26	0.26	11.69	106	1002
Sweet potato 1112 (SP1112)	93.15	6.85	4.54	0.39	2.55	2.95	0.07	0.08	0.02	0.22	0.25	11.69	106	1003/1150
Cassava root red	94.27	5.73	3.28	0.81	3.09	2.04	0.08	0.07	0.01	0.12	0.23	15.37	65	1004
Cassava root white (CASWht)	93.78	6.22	2.11	0.37	2.25	1.93	0.06	0.07	0.02	0.10	0.08	15.57	63	1005/1152
Feed mixtures:														
SPTIB1-5%Palm pit sediment (PPS)	89.55	10.45	4.32	2.24	2.07	2.87	0.11	0.14	0.14	0.22	0.23	11.47	105	1006
SPTIB1-10%PPS	89.68	10.32	4.39	4.16	2.06	2.82	0.10	0.13	0.13	0.21	0.22	11.81	105	1007
SPTIB1-15%PPS	90.19	9.81	4.21	5.86	2.33	2.71	0.10	0.12	0.12	0.19	0.25	12.20	105	1008
SPTIB1-20%PPS	89.62	10.38	4.39	7.75	2.20	2.70	0.11	0.12	0.13	0.22	0.26	12.45	104	1009
SPTIB1-25%PPS	89.65	10.35	4.43	9.49	2.06	2.72	0.10	0.12	0.12	0.19	0.25	12.78	104	1010
CASWht-5%PPS	89.47	10.53	2.10	0.94	2.46	1.87	0.07	0.09	0.05	0.10	0.10	14.93	62	1011
CASWht-10%PPS	89.39	10.61	2.19	1.90	2.32	1.88	0.08	0.06	0.02	0.11	0.11	14.98	62	1012
CASWht-15%PPS	89.6	10.4	2.24	3.86	1.84	1.90	0.07	0.06	0.03	0.11	0.12	15.09	62	1013
CASWht-20%PPS	89.61	10.39	2.40	5.47	2.13	1.95	0.06	0.06	[illegible]	0.12	0.12	15.16	61	1014
CASWht-25%PPS	89.7	10.3	2.44	7.10	2.21	2.06	0.07	0.06	0.03	0.13	0.14	15.25	61	1015
SPTIB1-5%Whole palm kernels (WPK)	87.77	12.23	4.38	2.83	1.99	2.80	0.09	0.13	0.13	0.17	0.25	11.11		1016
SPTIB1-10%WPK	88.15	11.85	4.69	4.70	2.15	2.74	0.10	0.14	0.13	0.19	0.22	11.33		1017
SPTIB1-15%WPK	87.78	12.22	4.92	6.36	2.29	2.72	0.10	0.15	0.13	0.19	0.22	11.47		1018
SPTIB1-20%WPK	87.21	12.79	5.13	7.57	2.49	2.70	0.10	0.16	0.13	0.20	0.24	11.57		1019
SPTIB1-25%WPK	88.53	11.47	5.50	10.13	2.71	2.59	0.10	0.15	0.13	0.22	0.23	11.92		1020

Composition of feed samples from the project field site in Cameroon, on an as received basis (%) - continued.

	Dry matter	Moisture	Crude protein	Ether extract	Crude fibre	Ash	Calcium	Phos-phorus	Salt	Lysine	Methionine + cystine	AME (MJ/kg)	Price/kg (FCFA)	Format No
Feed mixtures:														
SPTIB1-5%Palm kernel cake (PKC)	87.77	11.04	4.13	2.39	2.66	2.68	0.09	0.11	0.15	0.20	0.20	11.13		1021
SPTIB1-10%PKC	88.15	10.97	4.80	4.15	3.09	2.61	0.08	0.12	0.14	0.21	0.21	11.19		1022
SPTIB1-15%PKC	87.78	10.77	4.91	5.99	3.16	2.48	0.08	0.12	0.13	0.22	0.22	11.27		1023
SPTIB1-20%PKC	87.21	11.57	5.23	7.19	3.64	2.40	0.10	0.13	0.13	0.23	0.24	11.23		1024
SPTIB1-25%PKC	88.53	12.02	5.23	8.09	4.28	2.45	0.10	0.13	0.12	0.24	0.25	11.23		1025
CASWht-5%PKC	89.47	9.11	2.64	1.72	2.45	1.74	0.05	0.07	0.02	0.12	0.11	14.95		1026
CASWht-10%PKC	89.39	8.84	3.19	3.25	2.64	1.78	0.05	0.08	0.02	0.13	0.13	14.87		1027
CASWht-15%PKC	89.6	9.1	3.30	4.69	2.84	1.68	0.05	0.09	0.02	0.14	0.14	14.69		1028
CASWht-20%PKC	89.61	9.41	3.69	6.93	3.30	1.70	0.05	0.10	0.02	0.14	0.14	14.51		1029
CASWht-25%PKC	89.7	9.01	3.97	8.30	4.27	1.66	0.05	0.10	0.02	0.15	0.16	14.44		1030
CASWht-5%WKP	89.47	8.9	2.62	2.41	2.57	1.94	0.06	0.07	0.02	0.11	0.11	15.12		1031
CASWht-10%WKP	89.39	8.73	2.90	4.90	2.73	1.84	0.06	0.09	0.02	0.13	0.11	15.14		1032
CASWht-15%WPK	89.6	8.5	3.42	6.66	2.74	1.83	0.06	0.10	0.03	0.13	0.13	15.18		1033
CASWht-20%WPK	89.61	8.39	3.39	8.79	2.75	1.86	0.06	0.11	0.03	0.13	0.13	15.19		1034
CASWht-25%WPK	89.7	8.59	3.14	12.04	3.821	1.96	0.07	0.14	0.04	0.13	0.13	15.16		1035
SP1112-25% SP leaf meal	87.91	12.09	6.41	1.19	5.91	4.61	0.22	0.11	0.22	0.33	0.28	9.30	82	1042
SP1112-50% SP leaf meal	88.79	11.21	11.46	1.43	10.36	7.66	0.43	0.16	0.25	0.56	0.34	8.05	65	1043
CASWht-25% CAS leaf meal	86.63	13.37	7.94	1.07	4.81	2.50	0.24	0.09	0.02	0.47	0.35	12.31	48	1044
CASWht-50% CAS leaf meal	88.58	11.42	19.49	3.02	9.1	3.89	0.53	0.18	0.04	1.05	0.62	10.46	42	1045

Composition of feed samples from the project field site, on an as received basis (%) - continued

	Dry matter	Moisture	Crude protein	Ether extract	Crude fibre	Ash	Calcium	Phos-phorus	Salt	Lysine	Methionine + cystine	AME (MJ/kg)	Price/kg (FCFA)	Format No
Other local feeds (1994):														
Palm fruit fibre	**89.93**	**10.07**	**6.83**	**23.14**	**25.68**	**8.78**	**0.40**	**0.06**	**0.01**	**-**	**-**	**9.89**	**0**	**1111**
Infested maize (J.Ngwa)	92.41	7.59	9.95	3.07	3.04	1.64	0.01	0.30	0.01	0.34	0.58	12.01	0	1112
Wheat feed(Mbengwi)	90.59	9.41	16.80	4.13	5.74	4.03	0.08	0.78	0.01	0.63	0.90	9.56	0	1113
Roasted palm kernels	95.99	4.01	17.27	32.77	27.34	3.36	0.23	0.58	0.01	-	-	-	0	-
Fishmeal (MRS)	91.43	8.57	68.19	4.14	0.26	18.56	4.43	3.05	2.05	4.68	5.06	11.89	600	1114
Meat meal (Mbenbwi)	96.58	3.42	56.61	14.97	2.39	16.83	5.11	2.53	1.43	3.11	1.67	10.00	0	1115
Palm kernels (fruit boiled)	91.99	8.01	10.05	42.85	14.17	1.66	0.10	0.32	0	0.36	0.65	15.10	70	1118
Palm kernel cake (J.Ngwa)	91.21	8.79	13.50	27.89	15	1.97	0.16	0.38	0.01	0.57	1.04	12.33	70	1119
Dried brewers grains	92.5	7.5	21.09	1.63	14.87	6.95	0.37	0.62	0.23	0.60	1.10	9.94	0	1116
Palm pit sediment (direct pit)	80.91	19.09	5.97	40.78	6.85	12.82	0.92	0.06	0.07	0.30	0.43	17.51	6	1117
Blood meal	89.6	10.4	84.64	0.42	0.61	4.00	0.55	0.42	0.59	7.05	1.07	11.40	250	1100
Bone meal	99.4	0.6	2.30	0.13	0.10	96.93	30.52	12.58	0.08	0.28	0.15	0	75	1101
Bone meal - 1997	97.49	2.51	2.92	0.01	0.01	93.52	35.98	15.62	0.20	0.20	0.10	0	75	1104
Cottonseed cake	91.41	8.59	51.30	6.80	7.50	7.10	0.31	1.27	0.08	1.76	1.10	8.51	100	1102
Broken rice with chaff added	91.71	8.29	8.69	8.71	20.20	13.73	0.13	1.12	0.14	0.59	0.30	7.35	50	1099
Rice bran without chaff	91	9	12.70	13.70	11.60	11.62	0.07	1.54	0.10	0.65	0.37	11.50	75	1097
Oyster shell	99.73	0.27	0.80	0	0	97.69	34.01	0.26	0.35	0	0	0	80	1103
Palm Oil	100	0	0	100	0	0	0	0	0	0	0	33.45	550	1154
Palm kernel meal (commercial)	91.6	8.4	18.70	7.60	8.24	5.22	0.36	0.60	0.04	0.88	0.38	8.34	70	1121
Soyabean meal	90	10	44.10	1.40	7.02	6.48	0.27	0.61	0.13	2.78	1.29	9.27	400	1098
Lysine-Hcl	92.5	7.5	92.50	0	0	0	0	0	0	78.00	0	0	5000	503
Methionine	95	5	57.00	0	0	0	0	0	0	0	95.00	0	5000	504
Salt	97	3	0	0	0	97.00	0	0	97.00	0	0	0	165	502
Vitamin-mineral premix	95	5	0	0	0	61.75	0	0	0	0	0	0	23750	520
Ferrous sulphate	95	5	0	0	0	95.00	0	0	0	0	0	0	5300	

Composition of feed samples from the project field site, on an as received basis (%) - continued

	Dry matter	Moisture	Crude protein	Ether extract	Crude fibre	Ash	Calcium	Phos-phorus	Salt	Lysine	Methionine + cystine	AME (MJ/kg)	Price/kg (FCFA)	Format No
Solid-state fermented roots & tubers:														
SP1112 fermented 24 hrs	88.25	11.75	2.82	0.33	2.89	2.28	0.06	0.08	0.19	0.17	0.14	10.72	106	1036
SP1112 fermented 48 hrs	85.93	14.07	3.13	0.47	3.15	2.40	0.06	0.09	0.21	0.18	0.12	10.57	106	1037
SP1112 fermented 72 hrs	88.64	11.36	2.90	0.19	2.87	2.38	0.05	0.08	0.20	0.16	0.11	10.68	106	1038
CasWht fermented 24 hrs	86.4	13.6	2.35	0.29	2.94	1.98	0.08	0.06	0.02	0.14	0.10	14.08	62	1039
CasWht fermented 48 hrs	82.55	17.45	2.24	0.28	2.65	1.51	0.07	0.04	0.02	0.12	0.08	13.13	62	1040
CasWht fermented 72 hrs	80.37	19.63	1.96	0.44	2.53	1.74	0.07	0.05	0.02	0.10	0.08	12.05	62	1041
Means estimated from feed mixtures:														
Mean PPS	88.1	11.9	6.81	33.73	1.23	2.07	0.11	0.16	0.54	0.24	0.63	16.67	10	1048
Mean WPK*	90	10	10.35	43.12	3.09	1.97	0.11	0.31	0.07	0.27	0.39	14.87	20*	1049
Mean PKC	90.1	9.9	12.46	31.97	8.57	0.70	0	0.20	1.17	0.45	0.65	12.33	16	1050
Mean SP leaf meal	78.31	21.69	13.90	2.72	15.37	10.02	0.64	0.19	0.57	0.71	0.38	4.17	25	1046
Mean CAS leaf meal	74.28	25.72	26.61	3.77	12.31	4.49	0.76	0.20	0.03	1.52	0.98	5.22	25	1047
SP1112 fermented 48hrs	93.15	6.85	4.54	0.39	2.55	2.95	0.07	0.08	0.02	0.22	0.25	11.46	106	1151
CasWht fermented 48hrs	93.78	6.22	2.59	0.38	2.785	2.457	0.08	0.07	0.02	0.10	0.16	14.91	60	1153

* Note: retail price for third years feeding trials increased to 125 FCFA/kg. Format Raw material no in NRI's Feed Formulation software package.

Appendix 16.6. Composition of the diets in the variety evaluation and dried tuber and root shreds storage feeding trials on-station.

Table 1. Composition of the broiler starter diets (% unless otherwise stated).

	Control maize A	Sweet potato TIB1 B	Sweet potato 1112 C	Cassava White D	Cassava Red E	Sweet potato-TIB1-CSC/Fe F	Cassava White-CSC/Fe G	Sweet potato TIB1-CSC H
Fishmeal	8.99	10.00	10.00	5.97	6.13	2.43	6.65	2.42
Oyster shells	0.64	0.08	0	0	0	0.55	0.58	0.56
Bone meal	0	0.29	0.32	1.15	1.16	1.05	0.28	1.05
Blood meal	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Soyabean meal	16.98	16.11	18.17	32.49	31.83	0	0	0
Salt	0.23	0.21	0.21	0.23	0.23	0.29	0.25	0.29
Methionine	0.39	0.36	0.43	0.46	0.46	0.49	0.57	0.49
Palm oil	0	5.00	5.00	5.70	5.70	5.30	4.96	5.26
Palm kernel cake	5.00	11.77	13.07	0.39	1.94	0	0	0
Rice bran	1.89	0	0.17	0	0	0	0	0
Vitamin-mineral premix	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cottonseed cake	0	0	0	0	0	25.00	25.00	25.00
Lysine	0.16	0.06	0.03	0	0	0.65	0.51	0.65
Maize	62.22	12.62	9.10	10.11	9.05	20.68	17.64	20.78
Cassava - Red	0	0	0	0	40.00	0	0	0
Cassava - White	0	0	0	40.00	0	0	40.00	0
Sweet potato TIB1	0	40.00	0	0	0	40.00	0	40.00
Sweet potato TIB2	0	0	0	0	0	0	0	0
Sweet potato 1112	0	0	40.00	0	0	0	0	0
Ferrous sulphate heptahydrate	0	0	0	0	0	0.06	0.06	0
Total	100	100	100	100	100	100	100	100

Notes: The composition of Fav'solforte premix (made by Velta Animal Health) for administration in water used in the on-station trials supplied (per kg of powder): vitamin A 20,000,000 IU; vitamin D3 - 5,000,000 IU; vitamin E - 10g; vitamin B1 - 2g; vitamin B2 - 4.6g; vitamin B6 - 2.5g; vitamin B12 - 0.025g; vitamin C - 25 g; nicotinamide - 25 g; vitamin K3 - 3g; biotin - 11 g; folic acid - 0.5g; calcium pantothenate - 7.5g; methionine - 10g; lysine - 5g; zinc sulphate - 15g; ferrous sulphate - 15g; manganese sulphate - 15g; sodium chloride - 15g; copper sulphate - 2g.

Table 2. Calculated analyses of the broiler starter diets (% unless otherwise stated). Cost excludes vit-min premix cost.

	Control maize A	Sweet potato TIB1 B	Sweet potato 1112 C	Cassava White D	Cassava Red E	Sweet potato TIB1-CSC/Fe F	Cassava White-CSC/Fe G	Sweet potato TIB1-CSC H
As intended:								
Crude protein	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
AME (MJ/kg)	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25
Calcium	1.12	1.12	1.12	1.16	1.17	1.12	1.12	1.12
Phosphorus	0.60	0.60	0.60	0.60	0.60	0.65	0.65	0.65
Lysine	1.42	1.42	1.42	1.44	1.44	1.42	1.42	1.42
Methionine+cystine	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
Salt	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Cost (FCFA/kg)	245	237	243	259	258	215	207	211
As achieved:								
Crude protein	21.81	21.01	22.17	22.68	22.99	20.08	22.19	20.08
AME (MJ/kg)	12.21	12.27	12.16	12.45	12.31	12.26	12.42	12.26
Calcium	0.70	0.70	0.68	0.75	0.77	0.75	0.70	0.75
Phosphorus	0.60	0.60	0.60	0.59	0.60	0.63	0.64	0.63
Lysine	1.32	1.32	1.38	1.44	1.45	0.88	1.03	0.88
Methionine+cystine	1.51	1.28	1.39	1.32	1.34	1.10	1.36	1.10
Salt	0.46	0.46	0.46	0.41	0.41	0.38	0.43	0.38
Cost (FCFA/kg)	243	240	245	262	262	188	186	184

Table 3. Composition of the broiler finisher diets (% unless otherwise stated).

	Control maize A	Sweet potato TIB1 B	Sweet potato 1112 C	Cassava White D	Cassava Red E	Sweet potato TIB1-CSC/Fe F	Cassava White-CSC/Fe G	Sweet potato TIB1-CSC H
Fishmeal	7.23	9.99	10.00	9.76	10.00	0.77	2.51	0.41
Oyster shells	0	0.10	0	0	0.06	0.12	0.03	0.11
Bone meal	0.63	0	0.07	0.64	0.50	1.45	1.19	1.52
Blood meal	2.45	2.45	0.85	0	0.11	0.60	2.45	0.86
Soyabean meal	10.96	12.09	17.75	23.56	21.52	0	0	0
Salt	0.26	0.2	0.21	0.22	0.22	0.32	0.29	0.32
Methionine	0.14	0.07	0.11	0.03	0.05	0.09	0.21	0.10
Palm oil	1.50	7.00	6.95	6.20	7.00	7.15	7.11	7.15
Palm kernel cake	8.66	0	0.42	2.52	8.08	0	0	0
Rice bran	0.71	12.16	10.93	0	0	0	0	0
Vitamin-mineral premix	1.00	1.00	1.00	00	1.00	1.00	1.00	1.00
Cottonseed cake	0	0	0	0	0	25.00	25.00	25.00
Lysine	0.20	0	0	0	0	0.31	0.16	0.31
Maize	66.26	14.94	11.71	16.07	11.46	23.13	19.99	23.22
Cassava - Red	0	0	0	0	40.00	0	0	0
Cassava - White	0	0	0	40.00	0	0	40.00	0
Sweet potato TIB1	0	40.00	0	0	0	40.00	0	40.00
Sweet potato TIB2	0	0	0	0	0	0	0	0
Sweet potato 1112	0	0	40.00	0	0	0	0	0
Ferrous sulphate heptahydrate	0	0	0	0	0	0.06	0.06	0
Total	100	100	100	100	100	100	100	100

Table 4. Calculated analyses of broiler finisher diets (% unless otherwise stated). Cost excludes vit-min premix cost.

	Control maize A	Sweet potato TIB1 B	Sweet potato 1112 C	Cassava White D	Cassava Red E	Sweet potato-TIB1-CSC/Fe F	Cassava White-CSC/Fe G	Sweet potato TIB1-CSC H
***As intended*:**								
Crude protein	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00
AME (MJ/kg)	12.75	12.75	12.75	12.75	12.75	12.75	12.75	12.75
Calcium	1.00	1.00	1.0	1.17	1.17	1.00	1.00	1.00
Phosphorus	0.61	0.61	0.61	0.61	0.60	0.65	0.65	0.65
Lysine	1.23	1.23	1.23	1.23	1.23	0.95	0.95	0.95
Methionine+cystine	0.75	0.75	0.75	0.65	0.65	0.65	0.65	0.65
Salt	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Cost (FCFA/kg)	218	216	231	227	225	178	166	174
***As achieved*:**								
Crude protein	18.67	18.05	19.17	19.81	20.14	17.30	19.32	17.29
AME (MJ/kg)	12.70	12.78	12.66	12.94	12.81	12.78	12.95	12.78
Calcium	0.59	0.58	0.56	0.73	0.74	0.64	0.61	0.65
Phosphorus	0.61	0.61	0.61	0.60	0.60	0.63	0.63	0.63
Lysine	1.10	1.18	1.21	1.23	1.23	0.68	0.84	0.68
Methionine+cystine	1.14	0.96	1.06	1.01	1.03	0.63	0.83	0.63
Salt	0.44	0.46	0.46	0.45	0.46	0.36	0.38	0.36
Cost (FCFA/kg)	213	221	235	231	229	168	162	165

Table 5. Composition of the layer diets (% unless otherwise stated).

	Control maize A	Sweet potato TIB1 B	Sweet potato TIB2 C	Sweet potato 1112 D	Cassava White E	Cassava Red F	Cassava White - CSMFe G
Fishmeal	2.19	6.00	6.50	6.50	6.50	6.50	2.94
Oyster shells	6.63	6.06	5.98	5.97	5.96	5.92	6.23
Bone meal	1.97	1.89	1.78	1.83	1.83	1.90	2.09
Blood meal	0.62	0.26	0	0	0.62	0.55	0
Soyabean meal	18.00	16.55	17.97	18.39	23.73	23.82	0
Salt	0.29	0.23	0.23	0.23	0.22	0.22	0.27
Methionine	0.23	0.14	0.18	0.21	0.26	0.26	0.39
Palm oil	0	3.50	3.65	3.65	4.50	4.20	6.25
Palm kernel cake	5.08	1.83	0.80	4.94	0	0.11	0
Rice bran	0	0	0	0	0	0	0
Vitamin- mineral premix	1.00	1.00	00	.00	1.00	1.00	1.00
Cottonseed cake	0	0	0	0	0	0	25.00
Lysine	0.16	0	0	0	0	0	0.42
Maize	63.83	12.54	11.91	7.28	5.38	5.52	4.89
Cassava - Red	0	0	0	0	0	50.00	0
Cassava - White	0	0	0	0	50.00	0	50.27
Sweet potato TIB1	0	50.00	0	0	0	0	0
Sweet potato TIB2	0	0	50.00	0	0	0	0
Sweet potato 1112	0	0	0	50.00	0	0	0
Ferrous sulphate heptahydrate	0	0	0	0	0	0	0.25
Total	100	100	100	100	100	100	100

Table 6. Calculated analyses of the layer diets (% unless otherwise stated). Cost excludes vit-min premix cost.

	Control maize A	Sweet potato TIB1 B	Sweet potato TIB2 C	Sweet potato 1112 D	Cassava White E	Cassava Red F	Cassava White-CSMFe G
***As intended*:**							
Crude protein	16.50	16.50	16.50	16.50	16.50	16.50	16.50
AME (MJ/kg)	11.40	11.40	11.40	11.40	11.40	11.40	11.40
Calcium	3.40	3.40	3.40	3.40	3.40	3.40	3.40
Phosphorus	0.65	0.65	0.65	0.65	0.65	0.65	0.75
Lysine	0.98	0.98	0.98	1.01	1.09	1.08	0.98
Methionine+cystine	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Salt	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Cost (FCFA/kg)	211	201	201	208	210	211	180
***As achieved*:**							
Crude protein	16.01	15.07	16.14	16.50	17.37	17.72	16.82
AME (MJ/kg)	11.36	11.44	11.44	11.30	11.64	11.48	11.63
Calcium	3.02	3.01	2.96	2.98	2.98	2.99	3.00
Phosphorus	0.64	0.64	0.64	0.65	0.64	0.65	0.73
Lysine	0.89	0.92	0.98	1.00	1.08	1.09	0.65
Methionine+cystine	1.01	0.83	0.95	0.96	1.01	1.04	0.91
Salt	0.39	0.40	0.41	0.42	0.41	0.41	0.38
Cost (FCFA/kg)	209	208	214	213	213	215	162

Appendix 16.7. Data required for evaluating the processing characteristics of tubers and roots when considering their development into poultry feeds in different agro-climatic zones.

TRS[1] Plate combination or other process used	Throughput time for 100 kg of fresh	Drying time (hrs[2])	Particle size (Mean+sd) (mm*mm)	Ease of crumbing in hand (score 0-5) tuber	Clumpiness after drying (score 0-5)	Dustiness after grinding through 3 mm screen	Potential for direct feeding to layers (score 0-5)	Estimated cost of processing 1 kg of dry tuber (FCFA)	Other comments on feed texture
Sweet potato variety:									
A									
B									
C									
D									
E									
Cassava variety:									
A									
B									
C									
D									
E									

Note:s 1. Dito Sama Crypto Peerless Food Processor. 2. Time taken to dry to below 10% moisture. Detailed notes on temperature variation during the day while the chips are drying, spreading density (eg 4 kg of fresh material/sq m); if it takes longer than a day, was it brought and spread indoors. (Lack of time precluded these studies but it is shown here for guidance if the technology is considered elsewhere).

Appendix 16.8. Advice given to Test Farmer 'Male B' following the first on-farm trials to assist the development of small-scale commercial sweet potato tuber and cassava root-based poultry rations in the project area.

To
Mr Wilfred Fai
ETS FAI WILFRED M.
P.O. Box 337
BAMENDA
NORTH WEST PROVINCE
CAMEROON

21 January 1997

Dear Mr Fai

ENQUIRY ON ROOT-CROPS-BASED RATIONS FOR POULTRY AND PIGS

1. I apologise for this long delay in replying to your letter. The reason was that we were still completing our analysis of experimental results from the feeding trials conducted at Mankon, and I did not wish to provide you with ration formulae before we were satisfied with the data obtained.

2. Please find herewith some tentative broiler, and laying hen diets. I say 'tentative' for two reasons. Firstly, I have had to guess at the prices of feeds. Please, therefore, complete Table 1 with up-to-date prices of all the raw materials on the list, and of others available to you that I may have missed. Secondly, and perhaps more importantly, you will appreciate that giving the rations is not the end of the matter. We need to work together for at least a year or more to develop the rations that will meet with your objectives and constraints over the whole year. Due to the natural variability in the quality, nutrient composition and prices of feeds in different seasons, the best way forward is for me to suggest some rations to begin with. You may produce these and try them out with some small-scale poultry producers, keeping a good record of the performance of chickens in terms of feed consumption and weight gain of broilers and feed consumption and egg production of layers. If you then let me have the results together with your comments on how good (or bad!) the rations proved to be and what you would like to see included in or excluded from it (depending on availability of various feeds), I will modify the rations to improve them. This is what large feed manufacturers do to retain the confidence of their customers.

3. I have also given the calculated chemical composition of the diets for your information. However, these are guesstimates based on my previous experience in the region. Ideally, we need to analyse all the raw materials that you will use, but this is impractical and we do not have the funds for such a thorough approach. This should also point out a limitation of providing you rations from the UK. Nevertheless, if we work together we should develop good rations in the longer term.

4. Please take particular note of the prices that I have used to calculate the rations. It is especially important to point out that I have assumed that a vitamin and mineral package will be given to chickens in the water supply in accordance with standard practices in the region (please check with your customers). If on the other hand you add vitamins and mineral to the ration at a fixed rate, the composition of the ration will change in proportion (please advise on your requirements).

5. I have given you some options with each of the rations so that you may appreciate what is possible and how the cost changes with different alternatives. You will have to decide from poultry production records whether a particular option is worth your while pursuing (for example, the palm pit sediment option). If you would like particular raw materials to be included that is not already in the ration, please let me know their prices and the quantities available in different seasons.

6. For cassava root and sweet potato tuber you need to have these grated (as in garri, but with slightly larger particles) and then sun-dried. The chickens will prefer to eat small particles rather than ground meals. However, if grating is not possible, chipping and sun-drying within a day to below 12 per cent moisture, followed by grinding is a good alternative. If palm pit sediment from traditional pits is available, these should be added to the dried cassava grits or chips and sun-dried to below 12 per cent moisture. Palm pit sediment will be especially useful for broiler diets. However, it may be too much trouble for you (?), being labour-intensive. You will also need to provide me with a price that includes the cost of preparing it.

7. For broilers, I would strongly recommend that you suggest to small-scale poultry producers that it is a waste of time using starter and finisher feeds. The broiler rations I have given have been specially formulated to yield equally good production. Having two diets does nothing major for production overall, but increases the cost of producing the ration, and therefore, the price charged to the customer.

8. For egg production, a particular concern may be egg yolk quality. If the acceptability of yolk colour is poor, the ration will have to be suitably modified using a natural pigment source, such as cassava leaf meal. You will need to follow this up with an egg producer initially and find out what the customers of eggs say about egg quality. I will then advise on how a cheap pigment source may be added to the ration.

9. Please take particular note that the rations suggested are very specific in the ingredients they contain. The rations are designed such that you cannot leave out any ingredient or add more or less of it. They may appear similar but even slight changes to the 'wrong' ingredient could markedly affect the nutrient content and result in poor chicken production. If you have sudden problems in the availability of a particular feed, you must move on to a different formulae altogether. This is another reason that we need to work together. Please write to me about the problems of availability you face from time to time so that I may suggest alternative formulae for different bird types in these situations.

10. ***Palm oil sludge***. You should be able to make substantial savings on production cost if you obtain palm oil sludge, the waste from purification in commercial palm oil production. Like palm pit sediment, it is best to dry the sludge on to dried cassava or sweet potato meals in the proportions given by a ration. The sludge must be fresh and must not have been lying around for more than a week when you come to mixing the rations. The rations with palm pit sludge as an ingredient must also be sold off within 2 weeks, and farmers purchasing it must use it up within 2 months. If you wish to follow this option and produce rations that include palm oil sludge please let me have details of how it is produced in the factory, the quantities available to you and, of course, the price (in Table 1).

11. You may find some of the rations have too many ingredients but this is unavoidable if you wish to reduce the cost (done by avoiding high-cost maize). I have not yet formulated the pig grower diet that you requested, but will do so after you have examined the poultry rations and given me your comments on them and the up-to-date feed prices.

12. ***Quality of feed ingredients***. I should also point out that while these rations may appear cheap compared with commercial rations, you need to pay attention to the quality of several of the raw materials that you are buying. You need to be more careful than the large-scale animal feed compounder because your raw materials are what we describe as 'unconventional'. I have marked the ones on which you need to pay most attention in the Tables. For these ingredients, you will need to monitor the production process from time to time. For the blood meal you will need to inform the producer that the temperature at which blood is boiled is not allowed to rise very high. The oyster shells must be the 'burned' type from Limbe. Use of brewer's spent grains could save a great deal of money but the material has to be collected fast off the production process, drained quickly, and dried within 3-4 days. You should then get excellent results. I would even suggest that you need to employ someone to make trips to the brewery for this material on a regular basis and dry it for you.

13. ***Mixing feeds***. It is essential to get a very good blend when preparing poultry feeds. An attempt should be made to obtain a homogenous mixture even if very basic 'bucket' or 'floor & shovel' methods of mixing are employed. This can be achieved by adopting a step-by-step approach. Ingredients that are included in the ration in the smallest quantity (e.g. blood meal, fishmeal, bone meal, oyster shells, salt, etc.) must first be accurately weighed (a sensitive weighing balance is needed by a small-scale manufacturer of animal feeds!) and hand-mixed in a bucket, ensuring that there is no loss by wind blowing any feed particles away. Other ingredients should then be added to this (e.g. palm oil) and the blending continued. This mixture should then be transferred to a larger drum, or better still, a cement mixer if this is available. The mixture is therefore bulked-up gradually. The largest ingredient (cassava root, or sweet potato tuber) should be added last of all, and it is at this stage that floor mixing may be employed. Absence of colour patches or streaks in the mixture is used at each stage as a guide to how well the ration is being blended. In this regard, the white colour of cassava root or sweet potato tuber is particularly helpful.

14. Another important hint is to avoid the temptation to make a single very large batch of a ration that you hope will last for 3 months or longer, particularly when there are ingredients such as palm pit sediment, palm oil sludge and palm oil. I would suggest mixing small quantities every 3-4 weeks using fresh feeds as these are procured. This may increase your production cost because of extra labour requirements, but the customers of feeds will be more satisfied with the poultry production that results. Smaller quantities are also easier to blend. The minimum batch size will depend on the weighing balances you have. If you have an electronic 2 kg balance, you may mix small batches of 25 kg on a regular basis with very good poultry production results.

15. If you decide to follow my recommendations, I would be grateful if you would let me know the prices at which you start selling each of the ration and how this price changes with time as you begin to get the reactions of the poultry producers buying the feeds. A record of the prices charged will give me clues on how the different rations may be modified in the longer term, if you continue to seek NRI's advice in this matter.

16. I hope the information provided here is useful. I look forward to your reply as soon as possible. I am keen to know of your plans for developing the small-scale animal feed production and sale, as I believe that small-scale animal feed enterprises could play an important role in agricultural development in a way that will assist local small-scale, resource poor farmers.

Yours sincerely

Dr S. Panigrahi
Natural Resources Management Department

Table 1. Prices of animal feeds for a small-scale animal feed retailer in Cameroon [Mr Wilfred Fai, Box 337, Bamenda, North West Province, Cameroon] - Mr Fai to fill the Chart with up-to-date prices of feeds.

	Mid-dry season		Mid-wet season	
	Wholesale (FCFA/kg)	**Retail (FCFA/kg)**	**Wholesale (FCFA/kg)**	**Retail (FCFA/kg)**
***Feed raw materials*:**				
Sweet potato tuber, chipped, dried & ground	75	85		
Cassava roots, chipped, dried & ground	55	65		
Maize	110	120		
Fishmeal (good quality)	500	600		
Soyabean meal	340	360		
Cottonseed meal	72	86		
Palm kernel meal	30	50		
Blood meal	250	400		
Palm oil	400	500		
Wheat bran	50	60		
Rice bran with chaff	36	50		
Rice bran without chaff	60	80		
Brewer's dried grains[1]	35	50		
Bone meal	40	50		
Oyster shells (Limbe burned)	50	80		
Palm pit sediment (good quality)[2]	10	20		
Cassava leaf meal (good quality)	25	40		
Salt	30	40		
Palm oil sludge[3]				
Vitamin mineral premix				
Commercial rations (without premix):				
Broiler starter ration				
Broiler finisher ration				
Layer chick starter				
Layer chick grower ration				
Laying hen ration				
Pig grower ration				

Notes: 1. All procurement costs (including for processing and transporting feeds) costs must be included in the wholesale prices.

1. This must be collected and dried very quickly after it is released by the brewery.

2. Mix wet palm pit sediment with sun-dried cassava root (or sweet potato) grits or chips as follows: (i) Determine the approximate dry matter (DM) content of a sample of drained PPS. (ii) Assuming a dry matter content for sun-dried cassava of 90 per cent, calculate the weights of drained palm pit sediment and sun-dried cassava to obtain the ratio in the ration as fed. (iii) Prepare the necessary quantity of the wet palm pit sediment-cassava mixture and sun-dry to below 12 per cent moisture content. (iv). Grind the dried palm pit sediment-cassava mixture, if necessary.

3. This must be freshly produced. It is best to dry it on to cassava root or sweet potato tuber meals in the proportions given for a ration.

Table 2. Cassava root-based broiler rations for a small-scale animal feed manufacturer in Bamenda (diets to be fed from 0-8 weeks).

Ingredients (kg):	*Fai Broiler A (0-8 weeks)*	*Fai Broiler B (0-8 weeks)*	*Fai Broiler C (0-8 weeks)*	*Fai Broiler D (0-8 weeks)*
Ingredients (kg):				
Salt	0.127	0.152	0.135	0.144
Palm pit sediment[1,2]	5.000	5.000	-	-
Rice bran - no chaff	-	0.432	12.212	10.916
Soyabean meal	10.704	14.560	9.260	10.350
Blood meal[2]	2.000	2.000	2.000	2.000
Bone meal	0.768	1.132	-	-
Cottonseed meal	10.000	10.000	11.000	11.000
Oyster shells[2]	1.135	1.092	1.838	1.936
Fishmeal[2]	9.615	7.281	10.074	9.179
	10.946	-	3.481	-
	-	10.000	-	4.475
	49.705	48.351	50.000	50.000
	(in water)	(in water)	(in water)	(in water)
	100	100	100	100
	128.6	129.9	131.5	130.6
Analyses (% calculated):				
Crude protein	21.80	22.00	21.80	21.80
	1.20	1.20	1.20	1.20
	0.70	0.70	0.76	0.73
	0.40	0.40	0.40	0.40
Metabolisable energy (MJ/kg)	12.70	12.70	12.70	12.70
Lysine	1.22	1.19	1.22	1.20
Methionine+cystine	0.91	0.91	0.91	0.91

Notes: 1. Mix wet palm pit sediment with sun-dried cassava root grits or chips as follows: (i) Determine the approximate dry matter (DM) content of a sample of drained PPS. (ii) Assuming a dry matter content for sun-dried cassava of 90 per cent, calculate the weights of drained palm pit sediment and sun-dried cassava to obtain the ratio in the ration as fed (e.g. 5 kg: 49.70 5 kg for Broiler Diet A). (iii) Prepare the necessary quantity of the wet palm pit sediment-cassava mixture and sun-dry to below 12 per cent moisture content. (iv). Grind the dried palm pit sediment-cassava mixture (if necessary) for blending in the ration.
2. These must be good quality feeds.
3. This must be collected and dried very quickly after it is released by the brewery.
4. Chipped (or gritted), sun-dried, and ground if necessary.
5. It is assumed that the required vitamins and minerals will be provided in the drinking water.
6. Least-cost diet formulations on the basis of wholesale prices in Table 1.

Table 3. Cassava root-based layer chick starter (to be fed from 0-8 weeks) and grower (to be fed from 8-16 weeks) rations for a small-scale animal feed manufacturer in Bamenda.

	Fai Layer Chick Starter (0-8 weeks) A	*Fai Layer Chick Starter (0-8 weeks) B*	*Fai Layer Chick Grower (8-16 weeks) A*	*Fai Layer Chick Grower (8-16 weeks) B*
Ingredients (kg):				
Salt	0.251	0.257	0.298	0.257
Palm pit sediment	5.000	-	4.261	-
Rice bran - no chaff	15.000	15.000	19.379	19.944
Soyabean meal	4.347	3.186	-	-
Blood meal[2]	2.000	2.000	0.786	0.448
Bone meal	0.786	0.621	0.701	-
	7.000	7.000	7.000	7.000
	1.696	1.721	2.000	2.560
	4.311	5.365	2.549	3.161
	15.000	15.000	20.000	20.000
	15.000	15.000	15.000	15.000
	29.609	34.850	28.026	31.630
	(in water)	(in water)	(in water)	(in water)
	100	100	100	100
Cost per kg (FCFA)[6]	83.1	86.8	59.8	63.9
Analyses (% calculated):				
Crude protein	19.15	19.15	16.41	16.40
	1.20	1.20	1.20	1.20
	0.80	0.80	0.80	0.73
	0.45	0.45	0.45	0.40
Metabolisable energy (MJ/kg)	11.65	11.65	11.45	11.40
Lysine	0.95	0.96	0.73	0.73
Methionine+cystine	0.73	0.75	0.60	0.61

Notes: 1. Mix wet palm pit sediment with sun-dried cassava root grits or chips as follows: (i) Determine the approximate dry matter (DM) content of a sample of drained PPS. (ii) Assuming a dry matter content for sun-dried cassava of 90 per cent, calculate the weights of drained palm pit sediment and sun-dried cassava to obtain the ratio in the ration as fed (e.g. 5 kg: 29.609 kg for Chick Diet A). (iii) Prepare the necessary quantity of the wet palm pit sediment-cassava mixture, and sun-dry to below 12 per cent moisture. (iv). Grind the dried palm pit sediment-cassava mixture (if necessary) for blending in the ration.
2. These must be good quality feeds.
3. This must be collected and dried very quickly after it is released by the brewery.
4. Chipped (or gritted), sun-dried, and ground if necessary.
5. It is assumed that the required vitamins and minerals will be provided in the drinking water.
6. Least-cost diet formulations on the basis of wholesale prices in Table 1.

Table 4. Cassava root-based laying hen rations for a small-scale animal feed manufacturer in Bamenda (diets to be fed from 16 weeks to the end of laying period).

	Fai Laying hen (16 weeks-) A	*Fai Laying hen (16 weeks-) B*	*Fai Laying hen (16 weeks-) C*	*Fai Laying hen (16 weeks-) D*
Ingredients (kg):				
Salt	0.187	0.156	0.200	0.171
Palm pit sediment[1]	5.000	5.000	-	-
Rice bran - no chaff	0.709	-	-	1.975
Soyabean meal	13.727	9.908	13.932	10.560
Bone meal	1.811	1.347	1.803	1.157
Cottonseed meal	7.000	7.000	7.000	7.000
Oyster shells[2]	9.108	9.150	9.323	9.593
Fishmeal[2]	4.448	7.572	5.277	7.980
[illegible] meal	-	14.789	-	11.564
[illegible]	15.000	-	13.151	-
[illegible]	43.010	45.077	49.314	50.000
[illegible]	(in water)	(in water)	(in water)	(in water)
[illegible]	100	100	100	100
[illegible]	109.1	111.4	115.9	118.3
Analyses (% calculated):				
Crude protein	17.50	17.50	17.50	17.50
Calcium	4.00	4.00	4.10	4.10
Phosphorus	0.70	0.70	0.70	0.70
Salt	0.40	0.40	0.40	0.40
Metabolisable energy (MJ/kg)	11.50	11.50	11.50	11.50
Lysine	0.87	0.94	0.89	0.96
Methionine+cystine	0.75	0.75	0.75	0.75

Notes: 1. Mix wet palm pit sediment with sun-dried cassava root grits or chips as follows: (i) Determine the approximate dry matter (DM) content of a sample of drained PPS. (ii) Assuming a dry matter content for sun-dried cassava of 90 per cent, calculate the weights of drained palm pit sediment and sun-dried cassava to obtain the ratio in the ration as fed (e.g. 5 kg: 43.01 kg for Layer Diet A). (iii) Prepare the necessary quantity of the wet palm pit sediment-cassava root mixture and sun-dry to below 12 per cent moisture content. (iv). Grind the dried palm pit sediment-cassava mixture (if necessary) for blending in the ration.

2. These must be good quality feeds.
3. This must be collected and dried very quickly after it is released by the brewery.
4. Chipped (or gritted), sun-dried, and ground if necessary.
5. It is assumed that the required vitamins and minerals will be provided in the drinking water.
6. Least-cost diet formulations on the basis of wholesale prices in Table 1.

Table 5. Sweet potato tuber-based broiler rations for a small-scale animal feed manufacturer in Bamenda (diets to be fed from 0-8 weeks).

Ingredients (kg):	*Fai Broiler A (0-8 weeks)*	*Fai Broiler B (0-8 weeks)*	*Fai Broiler C (0-8 weeks)*	*Fai Broiler D (0-8 weeks)*
Ingredients (kg):				
Salt	0.151	0.142	0.165	0.158
Palm pit sediment[1,2]	5.000	5.000	-	-
Rice bran - no chaff	-	-	0.426	1.211
Soyabean meal	12.807	11.732	12.579	11.832
Blood meal[2]	2.000	2.000	2.000	2.000
Bone meal	1.219	1.071	1.090	0.915
Cottonseed meal	11.000	11.000	11.000	11.000
Oyster shells[2]	0.986	1.015	1.021	1.112
Fishmeal[2]	8.047	8.922	8.819	9.410
Palm kernel meal	-	4.048	-	2.362
Brewer's dried grains[3]	4.215	-	2.900	-
Sweet potato tuber[4]	40.000	40.000	40.000	40.000
	9.575	10.070	15.000	15.000
	5.000	5.000	5.000	5.000
	(in water)	(in water)	(in water)	(in water)
	100	100	100	100
Cost per kg (FCFA)[6]	154.9	155.6	160.2	160.8
Analyses (% calculated):				
Crude protein	21.80	21.80	21.80	21.80
Calcium	1.20	1.20	1.20	1.20
	0.70	0.70	0.70	0.70
	0.40	0.40	0.40	0.40
Metabolisable energy (MJ/kg)	12.40	12.40	12.40	12.40
Lysine	1.21	1.23	1.22	1.24
Methionine+cystine	0.91	0.91	0.91	0.91

Notes: 1. Mix wet palm pit sediment with sun-dried sweet potato tuber grits or chips as follows: (i) Determine the approximate dry matter (DM) content of a sample of drained PPS. (ii) Assuming a dry matter content for sun-dried sweet potato of 90 per cent, calculate the weights of drained palm pit sediment and sun-dried sweet potato tuber to obtain the ratio in the ration as fed (e.g. 5 kg: 40 kg for Broiler Diet A). (iii) Prepare the necessary quantity of the wet palm pit sediment-sweet potato tuber mixture and sun-dry to below 12 per cent moisture content. (iv). Grind the dried palm pit sediment-sweet potato tuber mixture (if necessary) for blending in the ration.

2. These must be good quality feeds.
3. This must be collected and dried very quickly after it is released by the brewery.
4. Chipped (or gritted), sun-dried, and ground if necessary.
5. It is assumed that the required vitamins and minerals will be provided in the drinking water.
6. Least-cost diet formulations on the basis of wholesale prices in Table 1.

Table 6. Sweet potato tuber-based layer chick starter (to be fed from 0-8 weeks) rations for a small-scale animal feed manufacturer in Bamenda.

	Fai Layer Chick Starter (0-8 weeks) A	*Fai Layer Chick Starter (0-8 weeks) B*	*Fai Layer Chick Starter (0-8 weeks) C*	*Fai Layer Chick Starter (0-8 weeks)) D*
***Ingredients (kg)*:**				
Salt	0.203	0.191	0.176	0.202
Palm pit sediment[1]	5.000	5.000	-	-
Rice bran - no chaff	-	-	-	-
	10.923	12.293	2.691	10.342
	2.000	0.095	2.000	0.053
	1.967	1.442	1.216	1.231
	7.000	7.000	7.000	7.000
Oyster shells[2]	0.697	0.870	0.972	0.945
Fishmeal[2]	4.455	7.108	7.272	7.938
Palm kernel meal	-	15.016	10.193	18.296
	16.955	-	18.000	-
	40.000	40.000	40.000	40.000
	8.800	7.985	6.480	9.993
	2.000	3.000	4.000	4.000
	(in water)	(in water)	(in water)	(in water)
	100	100	100	100
Cost per kg (FCFA)[6]	119.9	135.0	115.5	138.0
***Analyses (% calculated)*:**				
Crude protein	19.15	19.15	19.15	19.14
	1.20	1.20	1.20	1.20
	0.70	0.70	0.70	0.70
	0.40	0.40	0.40	0.40
Metabolisable energy (MJ/kg)	11.60	11.60	11.60	11.60
Lysine	0.99	1.05	0.98	1.05
Methionine+cystine	0.80	0.80	0.85	0.80

Notes: 1. Mix wet palm pit sediment with sun-dried sweet potato tuber grits or chips as follows: (i) Determine the approximate dry matter (DM) content of a sample of drained PPS. (ii) Assuming a dry matter content for sun-dried sweet potato tuber of 90 per cent, calculate the weights of drained palm pit sediment and sun-dried sweet potato tuber to obtain the ratio in the ration as fed (e.g. 5 kg: 40 kg for Chick Diet A). (iii) Prepare the necessary quantity of the wet palm pit sediment-sweet potato tuber mixture, and sun-dry to below 12 per cent moisture. (iv). Grind the dried palm pit sediment-sweet potato tuber mixture (if necessary) for blending in the ration.

2. These must be good quality feeds.
3. This must be collected and dried very quickly after it is released by the brewery.
4. Chipped (or gritted), sun-dried, and ground if necessary.
5. It is assumed that the required vitamins and minerals will be provided in the drinking water.
6. Least-cost diet formulations on the basis of wholesale prices in Table 1.

Table 7. Sweet potato tuber-based layer chick grower (to be fed from 8-16 weeks) rations for a small-scale animal feed manufacturer in Bamenda.

	Fai Layer Chick Grower (8-16 weeks) A	*Fai Layer Chick Grower (8-16 weeks) B*	*Fai Layer Chick Grower (8-16 weeks) C*	*Fai Layer Chick Grower (8-16 weeks) D*
***Ingredients (kg)*:**				
Salt	0.214	0.207	0.223	0.226
Palm pit sediment[1]	5.000	5.000	-	-
Rice bran - no chaff	4.245	17.338	16.836	11.253
Blood meal[2]	2.000	2.000	2.000	2.000
Bone meal	1.370	0.407	0.163	0.839
Cottonseed meal	7.000	7.000	7.000	7.000
Oyster shells[2]	1.067	2.239	2.182	1.687
Fishmeal[2]	5.813	3.504	6.142	4.786
Palm kernel meal	23.291	-	15.454	7.209
Brewer's dried grains[3]	-	21.397	-	15.000
Sweet potato tuber[4]	30.000	30.000	30.000	30.000
Cassava root	20.000	10.908	20.000	20.000
Palm oil	-	-	-	-
	(in water)	(in water)	(in water)	(in water)
	100	100	100	100
Cost per kg (FCFA)[6]	83.7	75.8	90.2	82.8
***Analyses (% calculated)*:**				
Crude protein	16.40	16.40	16.40	16.40
	1.20	1.20	1.20	1.20
	0.70	0.70	0.70	0.70
	0.40	0.40	0.40	0.40
Metabolisable energy (MJ/kg)	11.40	11.40	11.40	11.40
Lysine	0.87	0.76	0.88	0.80
Methionine+cystine	0.64	0.70	0.64	0.68

Notes: 1. Mix wet palm pit sediment with sun-dried sweet potato tuber grits or chips as follows: (i) Determine the approximate dry matter (DM) content of a sample of drained PPS. (ii) Assuming a dry matter content for sun-dried sweet potato tuber of 90 per cent, calculate the weights of drained palm pit sediment and sun-dried sweet potato tuber to obtain the ratio in the ration as fed (e.g. 5 kg: 40 kg for Chick Diet A). (iii) Prepare the necessary quantity of the wet palm pit sediment-sweet potato tuber mixture, and sun-dry to below 12 per cent moisture. (iv). Grind the dried palm pit sediment-sweet potato tuber mixture (if necessary) for blending in the ration.
2. These must be good quality feeds.
3. This must be collected and dried very quickly after it is released by the brewery.
4. Chipped (or gritted), sun-dried, and ground if necessary.
5. It is assumed that the required vitamins and minerals will be provided in the drinking water.
6. Least-cost diet formulations on the basis of wholesale prices in Table 1.

Table 8. Sweet potato tuber-based laying hen rations for a small-scale animal feed manufacturer in Bamenda (diets to be fed from 16 weeks to the end of laying period).

	Fai Laying hen (16 weeks-) A	*Fai Laying hen (16 weeks-) B*	*Fai Laying hen (16 weeks-) C*	*Fai Laying hen (16 weeks-) D*
***Ingredients (kg)*:**				
Salt	0.083	0.077	0.088	0.094
Palm pit sediment[1]	5.000	5.000	-	-
Rice bran - no chaff	5.224	5.941	10.785	9.721
Soyabean meal	6.803	6.120	4.362	4.989
Bone meal	0.573	0.414	0.267	0.337
	7.000	7.000	7.000	7.000
	9.852	9.935	10.000	10.000
	10.814	11.354	12.000	11.407
	-	2.159	2.498	-
	2.651	-	-	3.452
	30.000	30.000	30.000	30.000
	20.000	20.000	20.000	20.000
	2.000	2.000	3.000	3.000
	(in water)	(in water)	(in water)	(in water)
	100	100	100	100
***Cost per kg (FCFA)*[6]**	133.4	133.9	137.7	136.7
***Analyses (% calculated)*:**				
Crude protein	17.50	17.50	17.50	17.50
	4.10	4.10	4.10	4.10
	0.70	0.70	0.76	0.74
	0.40	0.40	0.40	0.40
Metabolisable energy (MJ/kg)	11.50	11.50	11.50	11.50
Lysine	0.97	0.98	0.99	0.97
Methionine+cystine	0.90	0.90	0.90	0.90

***Notes*:** 1. Mix wet palm pit sediment with sun-dried sweet potato tuber grits or chips as follows: (i) Determine the approximate dry matter (DM) content of a sample of drained PPS. (ii) Assuming a dry matter content for sun-dried sweet potato tuber of 90 per cent, calculate the weights of drained palm pit sediment and sun-dried sweet potato tuber to obtain the ratio in the ration as fed (e.g. 5 kg: 30 kg for Layer Diet A). (iii) Prepare the necessary quantity of the wet palm pit sediment-sweet potato tuber mixture and sun-dry to below 12 per cent moisture content. (iv). Grind the dried palm pit sediment-sweet potato tuber mixture (if necessary) for blending in the ration.

2. These must be good quality feeds.
3. This must be collected and dried very quickly after it is released by the brewery.
4. Chipped (or gritted), sun-dried, and ground if necessary.
5. It is assumed that the required vitamins and minerals will be provided in the drinking water.
6. Least-cost diet formulations on the basis of wholesale prices in Table 1

Appendix 16.9.Photographic records of project-developed manual tuber and root chipping gritting machines. (IRAD document reproduced in full).

MANUAL PROTOTYPE MACHINE

for

PROCESSING ROOT TUBERS

To be used in

CHICKEN FEED

Constructed by R T C Mfonta for

ODA - NRI - IRZV

Institute of Agricultural Research
for Development (IRAD)
Mankon Research Station
September 1997

Plate 1 (above) Logo on machines

Plate 2: Full view of chipper fro m the back (reference farmer's position).

(a) fly wheel, (b) chipper
(c) chute
(d) chipped product (there is a guard to protect chip s from scattering, removed for the picture).

Plate 3:
Front view showing chipper

Plate 4: Left view showing chute that holds tubers or roots.

Plate 5:
Right view showing flywheel to reduce labour force applied by operator.

Plate 6:
Top view of chipper.

Plate 7:
Top view showing mechanism that operates chipper.

Plate 8:
Front view of Pioneer chipper - operators complained this needed a lot of energy to operate.

Plate 9:
Back view of
Pioneer
chipper
showing
blades.

Plate 10:
Right view of
Pioneer chipper
showing
operating arm.

Plate 11: Top and left view of pioneer chipper. Closer view of blades and chute.

Plate 12: Female A operating machine. Machine at starting position for processing 5kg of cassava white (cw) or sweet potato (sp).

Plate 13:
Female A at
acceleration
position.

Plate 14:
Female A at
levelling
position.

Plate 15: Female A at position to apply force. Processed 5kg of tubers;sp; 48 seconds; cw, 1 minute.

Plate 16: Female B processed 5kg sat sp, 1min. 36 secs. ; cw 1min. 16 secs.

Plate 17:
Female C
sp. 43 secs.,
cw, 1min.
Feeding of
sp in chute.

Plate 18:
close up of
feeding of
cassava
into chute.

Plate 19:
Male A
Time:
sp 1 min. 8 secs.
cw 1 min.

Plate 20:
Male B
sp 52 secs.
cw 49 secs.

Plate 21: chipped sweet potato

Plate 22: Close-up of chipped sweet potato

Thickness 2-3 mm. Size variable according to tuber size.

Plate 23: chipped cassava white tubers.

PLate 24: Close up of chipped cassava white tubers. Thickness: 2-3 mm.

Plate 25:
Left view
of prototype
gritter.
(a) fly wheel
(b) chute.

Plate 26:
Right view of
gritter
showing fly
wheel.

Plate 27:
Front view
showing the
gritting box.

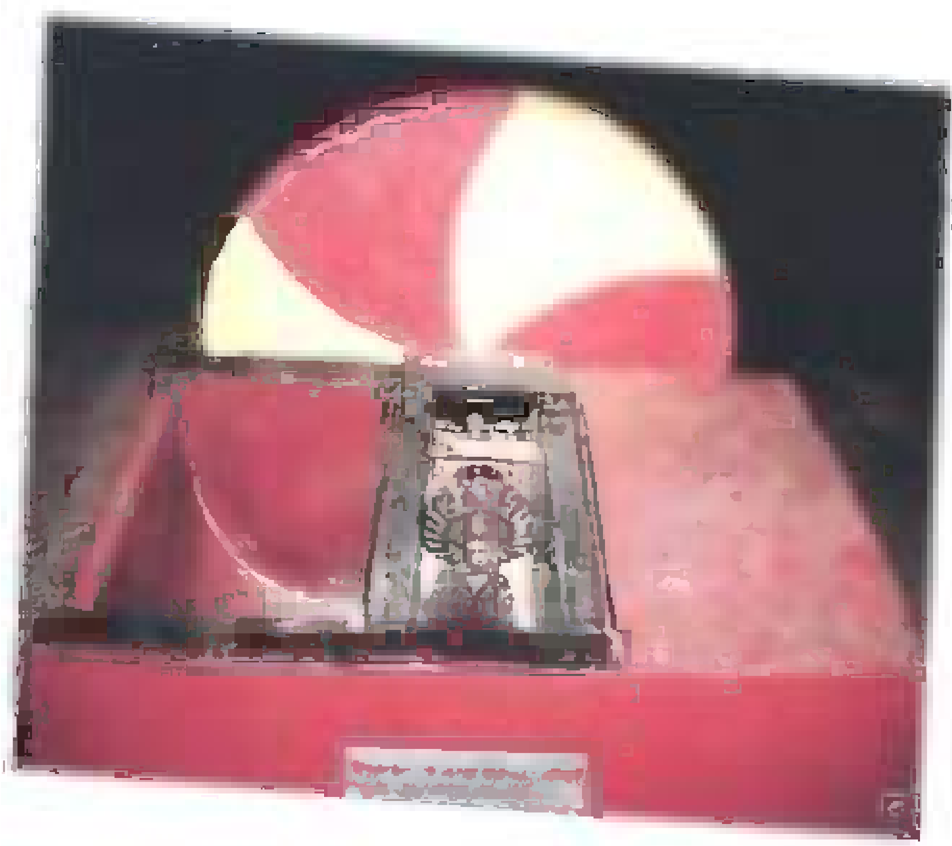

Plate 28:
Top view of
prototype
gritter
showing
bearings.

Plate 29: Left view of pioneer gritter. (a) gritting box. (b) chute to hold material. (c) sieve (d) operating arm.

Plate 30: Right view of pioneer griitter.

Plate 31:
Front view of
pioneer
gritter.

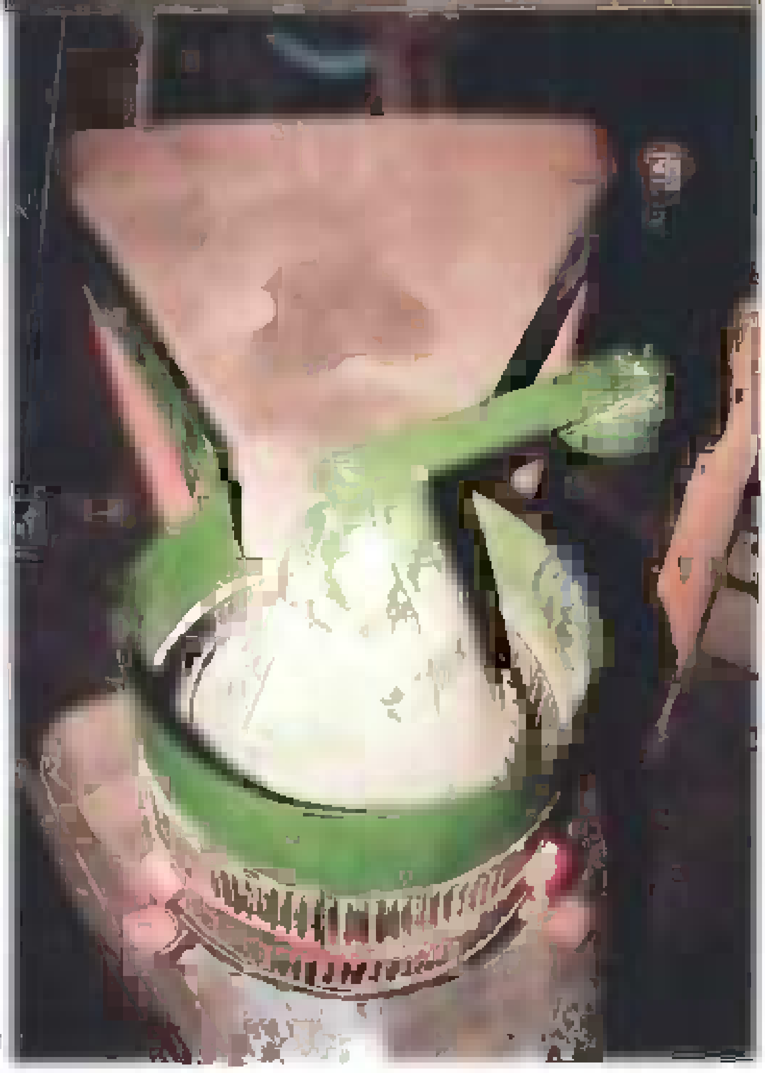

Plate 32:
Top view of
pioneer
gritter.