### 11.5.1. *Poultry farm characterisation study*

128. The objective of this study was to determine the type of poultry production systems prevailing in the region in terms of the resources, constraints and objectives of farmers, and the feed resources available to them. This information was required for (a) identifying the types of small-scale poultry production systems in which the project concept would make the greatest developmental impact for the target beneficiaries; (b) determining the poultry ration technology that would have widespread applicability, and thus, will be adopted by largest numbers of resource-poor farmers; and (c) the selection of demonstration farms for the project. The report is shown in Appendix 16.3.

129. The main findings of the survey as these related to project development were as follows. There are two types of small-scale poultry production systems in the region: the traditional backyard scavanging chicken, and the modern poultry sector where birds are more productive but require large quantities of feed. Researchers agreed that there was little scope for intensifying the traditional backyard poultry sector. The project focused on the modern poultry sector, as practised by small-scale producers. These producers are characterised by being sufficiently progressive and resource-able to keep hybrid chickens in confinement. These are found in peri-urban areas as a purely an income generating enterprise and in rural areas poultry was a sub-system within a mixed farming system.

130. Eighty-seven per cent and 47 per cent of broiler and layer farms, respectively, had flock size of less than 500 birds, and there was a tendency for farmers to keep chickens as a prinicipal farm activity as flock size increased above 1000 birds. Although an upper limit of 500 chickens of either broiler of layer type may reasonably be used to define a 'small-scale poultry producer' (paragraph 55), following closer study during 1995 researchers agreed that only those farmers who kept less than 500 birds of the broiler type and less than 250 hens of the layer type should be termed resource-poor in the project site region. Thus, farmers maintaining more than these numbers of hybrid chickens were excluded from consideration in relation to ration technology to be developed in this project.

131. The study also showed that for substantial proportion of small-scale producers poultry was a component of a mixed farming system in which the excreta represented a major co-product of the poultry system. Thirty eight per cent of broiler, 31 per cent of layer and 26 percent of mixed broiler and layer producers cited the use of manure for crops as being a major output of the poultry production system. This is related to the fact that in this region, with an average farm of 2 hectares, as much food as is possible, needs to be produced for the family. The high seasonal rainfall leads to considerable leaching of soil nutrients in this type of agro-ecological zone. For smallholders chickens, pigs, goats and rabbits are the important farm livestock manure source. Thus, rations generating excessive quantities of excreta due to low digestibility (as might be expected with fibrous feeds such as palm kernels and leaf meals) are not necessarily a major disadvantage in this production system.

132. The high cost of feeds was the single most important concern for producers, representing 60-64 per cent of the cost of poultry production (Appendix 16.3, Table 44). Since broilers were not marketed by weight but by feed, producers were particularly concerned if they could not sell off all their chickens within a short time of the birds reaching marketable size since each extra day in poultry house would require feed the value of which would not necessarily be recovered from the sale of those chickens. Of particular interest to examine what type of poultry producer practised on-farm mixing of compound diets (Appendix 16.3, Table 23). 77 per cent of farmers who mixed their own feed were those with flock size of more than 2500 birds. Most of these follow a prescribed ration formula that is based on concentrates sold by a large feed company. Significantly, 15 per cent of the total number of farms mixing their own feed were in the <500 flock size category. These farmers, however, do not follow a formulae but dilute purchased feed with on-farm resources in an apparently 'irrational' manner as far as nutrient balance is concerned. However, the fact that they attempt some form of ration mixing is an indication that they derive economic benefits from this practice. Investigations are needed to find out precisely what these benefits are in each case. It was agreed by

the project researchers that this may be a particular target group who could be assisted by the project-generated ration technologies. Other producers in the <500 bird category do not risk diluting commercial feed or preparing own ration formulae due to lack of knowledge of the feed resources available to them.

133. Deep-litter (79 per cent) and slatted-floor made from raffia bamboo (19 per cent) were the predominant poultry housing systems in the region, battery caging system constituting the remainder. This has major implications for the development of rations and transferring them to the target group, particularly for laying hens. To keep costs down and enable more work to be conducted in a short time it is necessary to use caged laying hens for experimental work on-station because this allows individual hen food intakes and egg production to be recorded and statistical analysis of results can be reliably conducted to ensure the validity of feed developmental research. However, transferring feed technology from a caged-hen on-station system to deep-litter and slatted-floor on-farm housing system may cause difficulties due to the higher energy expenditure of birds and the social behaviour associated with the latter group-housed systems. Both these factors might also be flock density-related.

134. The purchase of day-old chicks represented 25 per cent of the cost of broiler production (Appendix 16.3, Table 44), being second to feed costs. In recent years the cost of day-old chicks had risen sharply. Since young broilers are very sensitive to environmental and feed quality factors in terms of the presence of anti-nutritional or toxic compounds (it may take up to 9 days for chicks to develop physiologically) brooding and feeding are vital elements that need to be considered together. Brooding methods used for day-old chicks is of considerable importance in highlands where the nights are cold. Broiler growth will be influenced by this factor, which could then affect the utilisation of diets containing unconventional feeds. Whole house brooding is preferable but this is costly in both house design and energy usage. The survey showed that 91 per cent of producers practiced partial brooding but paid close attention to the chicks during the most sensitive periods. The energy source used were kerosene where bush lamps are used (71 per cent), electricity where light bulbs are used (30 per cent) and wood or charcoal where fire or stoves are used (4 per cent). For nutrition, it is essential to determine at what age various unconventional (nutritionally problematic feeds) should be introduced to chicks.

135. The distribution of the age and sex of poultry producers was of particular interest (Appendix 16.3, Table 33). Fifty two per cent of broiler producers but only 11 per cent of egg producers and 20 per cent of mixed broiler and layer farms were female-owned and operated. Most poultry producers were in the 30-49 age group. In suburban areas a significant proportion of female poultry producers were the wives of well-to-do professionals which excludes them from consideration as a target group under gender concerns. Occasionally, poorer women pool resources to operate a poultry production unit jointly as a group.

### 11.5.2. *Selection of farm types for targeted poultry ration development*

136. The poultry farm characterisation study formed the basis for selecting farm types for which poultry feed technologies would be developed, so that in turn, the rations would have a good chance of being adopted by target beneficiaries. For this the target poultry roducer was defined. Small-scale resource poor farmers generally operated mixed farming systems of which poultry was a component or operated in peri-urban areas. In either case, the farm types selected were those keeping a maximum of 500 broilers or 250 layers per production cycle. Only producers with slatted-floor and deep-litter poultry systems were considered, since caging systems were costly and beyond the reach of these producers. Thus, farmers who maintained more than these numbers of hybrid chickens were excluded from consideration. This constituted the target group for poultry ration technology adaptation and transfer. Amongst other factors, the ration needed to take account of potential complementary feed resources available to these groups, for example, palm fruit oil processing residues (See Section 11.5.5.)

### 11.5.3. *Selection of participants for the on-farm feeding trials*

137. The on-farm trials had two objectives. First, it was necessary to test the project-developed rations under the conditions of farmers for whom these would be developed. Secondly, the trials would serve the purpose of promotion and diffusion of project-developed technologies. Thus, in addition to selecting some resource-poor farmers, it was decided to select some individuals and institutions who could promote the technologies developed in the project. The poultry farm characterisation survey showed the need to keep roughly 50:50 percent of male and females in these farms. Although few females kept layers, there was a need to conduct on-farm trials with some women to determine if more could be encouraged in this activity.

138. It was considered that both the objectives for the on-farm trials could be met if the following six categories of farmers and organisations were selected for the on-farm feeding trials:

(a) one small-scale male poultry producers involved in crop-farming and off-farm employment.

(b) one small-scale male poultry producer who with his family was involved in crop-farming but also owned a small-scale animal feed trading shop. This selection was made because it was considered that this person would be able to organise the local production of SP cand CAS by small-scale farmers and then produce and sell cheap feeds to serve the diffusion element in the objectives.

(c) two, small-scale female group poultry producers.

(d) Cameroon Women Income Development Cooperative (CAMWIDCO) a union of women group producers. This organisation is comprised of more than 50 individual women groups producing crops in the rural areas. The project-developed technologies could therefore be easily disseminated to thousands of rural women through its participation.

(e) Presbetarian Rural Training Centre (PRTC), a NGO involved in training agricultural extension workers in all aspects of farming, including crop, livestock and agro-forestry. Thus, it would provide another pathway for diffusion of project-developed technologies. A second reason was that PRTC has an strong engineering component, developing on-farm tools, and equipment for small-scale food processing such as cassava graters for garri production. PRTC has cooperated by contributing some of its own resources to develop the manual gritting machine, which is seen as a vital component of the package of technologies being developed by the project.

(f) one, respected village leader who guides local farming activities.

139. It should, however, be noted that transport costs in the highlands are extremely high and MRS vehicles were old. In order that researchers could coordinate project activities and supervise the on-farm feeding trials, all the participating farms were selected to be in the vicinity of the MRS except for the PRTC, which was furthest at 30 km.

### 11.5.4. *Identification of local varieties of sweet potato and cassava*

140. CIP has its Central and West Africa Regional Station at Bambui within the facilities of IRA. Mr J. Koi of CIP and Dr P. Tchamo (Chief of IRA) provided valuable advice on the type of sweet potato varieties being cultivated and being considered for future release in different agro-climatic zones of Cameroon. Based on these discussions, three varieties of sweet potato (TIB1, TIB2 and 1112) were cultivated during Year 1 for the on-station poultry feeding trials. The SP were grown by CIP in IRA fields. From Year 2 onwards MRS cultivated the tubers on their fields in order to retain greater control over its production and processing for project work, IRA being 20 km away from MRS.

141. For cassava, MRS sought the advice of IITA, who were still in the process of setting up offices in Yaounde, and evaluating data of potential cassava varieties in Cameroon. High-cyanide varieties of CAS have now largely been replaced by low-cyanide varieties. The two most common varieties cropped all over Cameroon are cassava white and cassava red, which were both low in cyanide, so that the rate of drying chips was not a factor to be taken into consideration for processing (paragraph ). Because of their distinctive appearance and abundance it was decided to purchase these varieties from the market for project work rather than growing them, which would have been costly.

### 11.5.5. *Traditional rural cooking oil extraction from palm fruits*

142. The traditional method oil extraction from palm fruits is elaborate and labour-intensive, using up much of a day. The palm tree is a smallholder cash crop of major importance in West Africa. The tree produces a bunch of fruits (approximately 8 kg of fruits) and yields 2-3 crops a year (year-round cropping). When a bunch is ripe one or two fruits fall down which is the indication that the bunch should be harvested. A person climbs up the palm tree and cuts the bunch which falls to the ground. Villagers process the palm fruit using a pit method for extracting oil for own use and for sale. The process involves boiling the fruit until soft. The boiled fruits are then put in a platform that slants into a pit which is full of water. Men and women stand walk on the boiled fruits squeezing them with their feet whilst holding on to a bamboo pole placed above their head to prevent themselves from slipping and falling. A person stands in the pit and casts pit water into the feet of the the people pressing the fruits to assist in the extraction of high oil pulpy material which then runs into the pit. All the fibrous elements of the palm fruit and the palm kernels remain on the pit platform, from where palm fruit fibre and whole palm kernels (WPK) are separated.

143. After some time the palm oil floats to the surface of the pit water from where it is skimmed off and placed into a large pan. The pan is heated to drive out all the moisture, a point arrived when foaming begins. When clear oil with small particles are left, the clear oil is filtered through a hollow cattle horn that has a hole at the pointed end and a filter made from palm leves is placed inside. The oil is now ready for sale. The palm fruit residue remaining in the pit is termed palm pit sediment (PPS) and dilute slurry. These are normally discarded through a channel, where pigs may be allowed to consume the slurry as a wet feeding system. However, it is common to let out the slurry and sediment to run off quickly because on drying PPS become a hard like concrete-like cake which poses a major pit maintenance problem for the villagers. The run-off, however, represents a pollution problem affecting the local soil and contaminating ground water, of which there may be a shortage in the dry season in many villages in there may be a shortage of water in many village in highlands.

144. The second aspect of traditional rural oil extraction from palm fruits involves the production palm kernel oil, which sells for approximately four times the price of palm oil and is used as cosmetic oil, or for its health properties. Whole palm kernels are ground using a corn mill. Water is added at a ratio of 2:1 and the mixture is boiled over log fire for about 2 hours. Oil floating over the water is collected and more water is added as it evaporates during the oil extraction process. When the oil processing is complete, the water is strained to remove the palm kernel cake (PKC) and oil-

water mix heated to remove the moisture. The oil is then bottled for own use or for sale. Production of palm kernel oil by this method is, however, sporadic and may be considered environmentally unsustainable in terms of energy use.

145. Following the RRA in the prefeasibility study, it was considered that the PPS should have a high energy value (due to the residual oil content) and should contain vitamins, minerals and pigments for yolk and carcass colouration. It could be used for rural poultry production if the sediment was lifted out of the pits using a pan, mixed with sun-dried CAS and SP grits or meals, then further sun-dried to form a tuber- and root-PPS mix feed resource.If the technology was successful it would not only solve a local environmental problem, it would add value to an underutilised or wasted resource. Similarly, WPK and PKC represent potential rural feed resources for peasant poultry production. NRI has promoted a concept of integrated oil milling cum poultry production as an agricultural system in developing countries (Panigrahi, 1995) to assist the viability of rural small-scale oilseed processing and cultivation of traditional crops, which increasingly find it difficult to compete with large-scale industrial processing of introduced oilseeds such as soyabeans. This system of integration promotes rural income generation by resoure-poor farmers in both oil milling and poultry rearing activities. It was, therefore, decided to investigate the use of these resources as complementary feeds to SP and CAS in poultry ration development in the present project.

### 11.5.6. *Development of adaptive feed mixtures and sampling of complementary feeds for analysis*

146. The purpose of these activities was to adapt the rations to be consistent with the resources, constraints operating and opportunities available to the small-scale poultry farmers identified as the target beneficiaries of the project, in order that the on-farm trials could be appropriately designed. Approximately forty feed mixtures were developed for the assessment of feed texture and nutritional value in MRS and 5-6 kg samples were air-freighted (Appendix 16.4). In addition, during 1994 and 1995 MRS collected samples of a range of different feeds at different seasons of the year which were considered to have potential for use in poultry rations in the project field site, for nutritional analysis at NRI (NRI Phase 2 studies). The local prices of the feed materials were also recorded (Appendix 5). The following feeds and feed mixtures were analysed at NRI: local maize, three varieties of SP and two of CAS (see paragraph 112), PPS, WPK, PKC, solid state fermented SP and CAS, SP and CAS with their respective leaf meals, and a range of other local agricultural and slaughter house by-products. Details of the processing involved in these feed raw materials are as follows.

147. *PPS.* PPS was collected oil extraction pits in Mbwengi. After the farmers had finished extracting oil from palm fruits (paragraphs 140-141), the left-over water in the pit was allowed to stand for one hour to enable the sediment to settle and become thick. The sediment (PPS) was collected into PVC bags and the mouth sewed with nylon ropes. Heavy stones were placed on the bags to squeeze as much of the the excess water out as possible. The thickened PPS was mixed with CAS or SP in different proportions in small batches and sun-dried. However, for the first on-farm feeding trials for logistical reasons (larger quantities required) the thickended PPS was brought to MRS and sun-dried on a cement floor slab for two days. For the PPS sample analysed in NRI and for the material prepared for the first on-farm trials (including the on-station testing stage) the PPS was collected from pits into bags amd pressed at the point of collection. It was transported from Mbengwi to MRS and sun-dried on water proof paper on a cemented slab for about 23 hours. The final dry matter content was 12.1 per cent.

148. *WPK.* The best grade of palm kernels originating from the traditional methods of palm oil processing were purchased from MRS neighbouring markets. These were ground coarsely in a the MRS feedmill for the first on-farm trials.

149. *PKC.* Whole palm kernels of the best grade were ground using a corn mill and processed as described earlier (paragraph 142). The PKC was collected into a bag, which was then pressed to remove more water. The PKC was then removed and sun-dried over 16 hours.

150. *SP and CAS meals*. The dry matter content of the three varieties of SP were around 32 per cent, while for the cassava it was between 40-42 per cent. For the first on-station feeding trials, SP and CAS were processed using the J3 plate of the TRS vegetable preparation machine. The tubers and roots were washed and processed to produce 4-10 cm shreds which were then sun-dried, a process that took 7-10 hours. However, following the tuber and root gritting trials (see section 11.5.10), the AS4 plate of TRS was used for project work as producing the optimal processing and drying characteristics for efficient progress of the project activities. Dried samples were ground for inclusion in the rations.

151. *Solid-state fermented SP and CAS*. For the first NRI Phase 2 studies, SP and CAS were gritted using the J4 plate of TRS. The grits were placed in jute bags and the mouths sealed with nylon ropes. The bags were kept indoors at about 30$^{o}$C for 24, 48 or 72 hours before being sun-dried (or air-dried indoors using fans when raining). For the third on-station feeding trials (1997-1998), the AS4 plate of TRS was used. Photographs illustrating the drying process are shown in Appendix 14).

152. *Sweet potato leaf and vine meal (SPLM)*. For the NRI Phase 2 studies, sweet potato leaves were collected from farms around MRS. As this collection took place during the rainy season, the leaves were sun-dried whenever the sun was shining and air-dried within the building corridors of MRS using two table fans for one week. The dried leaf meals were ground through a Tecator 1093 grinding mill. The dry matter content was found to be 23.3 per cent. It was then mixed with sun-dried SP at 25:75 or 50:50 ratio.

153. *Cassava leaf meal (CLM)*. The cassava leaves for the NRI Phase 2 studies were also obtained in the rainy season when plants were growing had a high foliage cover. The leaves were sun-dried whenever the sun was shining and air-dried within the building corridors of MRS using two table fans for one week. The dried leaf meals were ground through a Tecator 1093 grinding mill. The dry matter content was found to be 22.08 per cent. It was then mixed with sun-dried CAS at 25:75 or 50:50 ratio. The leaves used in the third on-station broiler and layer feeding trials (1997-1998) were obtained at the end of the dry season when tubers were harvested and plants had low foliage cover. There are several uncertainties to consider in the use of CLM. First, the time of leaf harvest could affect its dry matter content, nutrient content, digestibility of nutrient, and cyanide content (and hence toxicity to chicks). Second, it is not known what effects the method of processing used in this project will have on the cyanide content of samples taken in the wet and dry seasons. With cassava roots, it was found that the rate of drying chips caused a marked reduction in cyanide content and poultry production (Panigrahi, *et al.*, 1992a) but it is not clear whether this applies to cassava leaves. It is generally accepted that tubers need to be chopped with the peel for linamarase to be released to enable the removal of cyanide, but it is again not clear whether leaves should also be chopped before sun-drying to remove cyanide. Third, for both SP and CAS the point in the growing season that leaves are harvested will influence tubers and root yield. This consideration is complicated by the facts that in the rainy season plants have more leaf cover for harvest than in the dry season when tubers are available for harvest, and further that in many farming systems including those in the MHAZ it is necessary to prune the leaves during the growing season as a pest control measure. The CLM samples used in the NRI Phase 2 feeding trial was obtained in the wet season, and it gave good results. However, for the third on-station feeding trial (1997-1998) CLM of necessity was harvested in the dry season so that there was still some uncertainty on its nutritional value for poultry at the time of testing.

154. *Bone meal*. Bone meal is a valuable source of calcium and phosphorus for the rural poultry sector in West Africa, where beef is cut and sold in all rural and urban meat markets. In 1994, due to the enonomic depression, bones were generally discarded in many markets in the project site and so could easily be acquired by small-scale processors to convert into bone meal. However, by 1996, there was a price for it and it appeared to be on the increase. Small scale processors may use several methods of preparing it, the most common in the project site region being either to burn the bones in an oven (or roasted over open fire) until they become grey in colour. Buring is necessary not only to

kill harmful micro-organisms but to render the bone easy to crush. It is generally done using the carcass fat as fuel. The resulting material may be called calcinated bone meal. Feed millers and nutritionists should take note that bone meal may sometimes by contaminated with horns and hoofs of cattle, which have very low calcium and phosphorus contents (Gohl, 1981, p 395-398).

155. *Blood meal.* Blood is available from local slaughter houses in quantities that varies with the season. In the dry season, less blood is available than in the wet season. However, the market for blood meal produced by small-scale processors was not well-established, resulting in low prices. Small scale processors can collect the blood and process them using simple techniques, such as boiling and spray drying. It is commonly boiled in pans over open fire until blood has coagulated and water evaporated. However, the nutritive value is dependent on the temperature of boiling, which should not rise above 120°C at any stage. Blood should be boiled very slowly and stirred continuously and then spread over a concrete floor in a well ventillated room to cool and dry completely (Gohl, 1981, p 393). Whether all processors are aware of this is doubtful so that ration incorporation rate was limited to 2.5 per cent in the present project. A better method for using blood is to absorb it onto wheat middlings or rice bran and then heat from below or spread it in the sun to dry. This recommendation was however not practicable in the project field site due to the fact that blood is already partly coagualated before the small-scale processor can process it.

156. *Other feed raw materials.* Other feed resources available in the project site that were complementary to SP and CAS for ration formulation were sampled for analysis. These included fishmeal, wheatfeed, meat meal, brewers dried grains, cottonseed cake, rice bran (with and without chaff), broken rice, oyster shells, palm oil, commercially processed palm kernel meal, and soyabean meal. The proximate analysis of the feed samples were conducted at the National Nutrition and Biochemistry Laboratory (NBL) in Cameroon (see Appendix 16.3, Table 24). Some of the important analyses required for formulating rations (e.g. the mineral content of feeds) could not be conducted in Cameroon and were conducted in NRI. Subsequently, the scope of this analysis was extended to include amino acid composition and metabolisable energy values of the feeds to develop a feed composition chart (paragraph 107) for the project area. The results of NRI analyses are shown in Appendix 16.5.

### *11.5.7. Testing tuber and root-based rations on-station before on-farm feeding trials*

157. The main objective of this project was the development of low-maize or maize-free ration formulae and associated feed technology that would be suited to adoption by small-scale farmers. The tuber and root gritting technology is an essential component of the strategy adopted to meeting this objective, but it was recognised that this technology will require time to develop and its success was by no means assured. The gritting trials and ration formulae development and transfer were, therefore, conducted in parallel in the expectation that if both aspects could be resolved by the final stages of the project, the two components could be packaged for one set of recommendations to small-scale farmers. This approach necessarily entailed the development of ration formulae using mash feed.

158. The NRI Phase 1 strategic research findings concerning the importance of cultivar and processing conditions on the nutritive value of sweet potato (paragraphs 97-108) and cassava were incorporated in the design of the ration development field studies in several ways. First, the three varieties introduced by CIP and cultivated in large quantities in the region (TIB1, TIB2 and 1112) and the two varieties of cassava (red and white) needed to be evaluated in on-station feeding trials in order that the SP and CAS varieties optimal in terms of processing charactericss and high nutritive value were used in planning the on-farm rations. Second, all on-station and on-farm poultry feeding trials in relation to ration development were conducted with unpeeled raw materials, since the cost of labour and waste generated from peeling represented costs that were considered to too high to be compensated for by the higher nutritive value (up to 20 per cent as assessed by TDF). Third, the results indicated that field work must be conducted in the dry season (December-March) because of

the possible adverse effect of environmental humidity on nutritive value of SP during drying (as indicated by the results of the NRI Phase 1 studies). Fortunately, this decision was in accord with the farming systems of the region, as sweet potato is the only crop productive enough for the late (second) plantings in July so that it is ready for harvest during the dry season; and because considerably more labour is available in this season for the root processing work required by the ration technology proposed.

159. There were four inter-linking aspects to the on-station poultry feeding trials. These were: (a) assessment of the potential for including sun-dried, local varieties of SP and CAS with suitable agronomic characteristics of high yield and disease resistance, in broiler chick and laying hen diets; (b) assessing the storability of the sun-dried SP and CAS during the rainy season; and (c) developing the nutritional approach for the design of the socio-economically optimal poultry rations for the target beneficiaries; and (d) testing rations designed for farmers under researcher control in order to obtain reliable poultry performance data to ensure the suitability of the rations before on-farm testing under farmer control.

### 11.5.7.1. *Broiler 1 and layer 1 feeding trials to evaluate local varieties of tubers and roots*

160. For the first on-station trials, it was essential to ensure the purity of the tubers from the TIB1, TIB2 and 1112 varieties of sweet potato. Another consideration was the need for sweet potato to be cultivated specially for the project so as not to disrupt the local economy by the removal of large quantities from the market. For sweet potato cultivation the assistance of the local CIP and IRA research stations (in Bambui) was sought, and a collaborative programme of work agreed. The three varieties were cultivated on separate fields on IRA premises (Bambui) by the local CIP staff. However, due to insufficient planting material, the quantitiy of TIB2 produced proved inadequate for both the broiler chicken and laying hen feeding trial, as required by the experimental design (see below). Nevertheless, sufficient material was available to make valid comparisons of varietal differences.

#### 11.5.7.1.1. *Dietary treatments*

161 The dietary treatments for the broiler trial were:

- A Control diet (containing >60 % maize, as in the commercial poultry feeds)
- B 40 % sweet potato tuber meal (variety TIB1)-based diet
- C 40 % sweet potato tuber meal (variety 1112)-based diet
- D 40 % cassava root meal (variety White)-based diet
- E 40 % cassava root meal (variety Red)-based diet
- F 40 % sweet potato tuber meal (variety TIB1)-based diet including ferrous sulphate-treated cottonseed cake (CSC) at 25%
- G 40 % cassava root meal (variety local white)-based diet including ferrous sulphate-treated CSC at 25%
- H 40 % sweet potato tuber meal (variety TIB1)-based diet including untreated CSC at 25 %

162. The dietary treatments for the layer trial were:

- A Control diet (containing >60 % maize, as in the commercial poultry feeds)
- B 50 % sweet potato tuber meal (variety TIB1)-based diet
- C 50 % sweet potato tuber meal (variety TIB2)-based diet
- D 50 % sweet potato tuber meal (variety 1112)-based diet
- E 50 % cassava root meal (variety local White)-based diet
- F 50 % cassava root meal (variety local Red)-based diet

G 50 % cassava root meal (variety local White)-based diet including ferrous sulphate-treated CSC at 25 %

**11.5.7.1.2.** ***Nutritional considerations in designing dietary treatments***

163. The main objective of these feeding trials were to determine whether it was technically possible to incorporate high levels of SP and CAS into broiler and layer diets without major losses in production with respect to a maize-based diet, and to select varieties of each commodity for further development of the project. Accordingly, Diets A-E of the broiler trial and Diets A-F of the layer trial tested the use of SP and CAS at 40 and 50 per cent dietary inclusions respectively (Appendix 16.9, Table 1, 3 and 5). For effective comparison, nutritionally-balanced rations were required. The broiler starter diets were formulated to contain 22 per cent crude protein (CP) and 12.25 MJ/kg apparent metabolisable energy (AME); broiler finisher diets 19 per cent CP and 12.75 MJ/kg AME, and the layer diets 16.5 per cent CP and 11.40 MJ/kg AME. However, attempts were made to keep all other major nutrients at the same levels in all experimental diets in order to make comparison valid (Appendix 16.9, Table 2, 4 and 6; *as intended* figures).

164. The limitations of this approach in relation to the financial viability of dietary treatments should be noted. The approach is based on the consideration that to compare the potential of different varieties of a test feed, each variety needs to be analysed for nutritional composition using chemical analysis (SP varieties may differ in CP and AME considerably) and diets then need to be formulated to a common nutrient specification. For this compromises need to be made on both complementary ingredient and nutrient contents of the rations. For ingredients, unconventional complementary feeds needed to be fixed at the same level in all test rations or if toxic principles are present they need to be avoided altogether even if such feeds are the cheapest available and have some potential for use. Thus, the control (maize) diet was forced to contain 2.5 per cent blood meal, the level found to be required for some of the other rations, because there was uncertainty on the quality of the product prepared by small-scale local processors (paragraph 153). The rations omitted CSC, which contains the toxic polyphenolic compound gossypol and cyclopropenoid fatty acids that cause losses in poultry productivity and discolourations in eggs (Panigrahi, 1992). For nutrient, an example of the type of compromise that is inherent in the approach is that if one variety contains a higher lysine content, lysine (synthetic or from other costly feeds such as fishmeal) would need to be added to other diets to bring it up to the lysine content of this ration, even though the rations then contain higher levels of lysine than is required by the chickens. Similar problems arise in balancing other major nutrients.

165. This type of ration manipulation to ensure all diets contain the same level of the major nutrients inevitably leads to diets not being least-cost in relation to the production potential of each. The diets are however least cost within the constraints imposed to balance the nutrients for effective comparison of treatments. Thus, the ration cost was not a major consideration in the design of the feeding trials, the main objective being to compare varieties for their nutritional value. Moreover, in order to balance nutrients, it proved impossible to completely eliminate maize completely from the SP and CAS based rations. Finally, the chemical composition of commercial feeds sold in Cameroon is unknown as there are no legal requirements for this information to be declared on each bag of feed sold (Appendix 16.4, Section 3.2.3.1. d & e). This meant that there was no possibility of ensuring the experimental rations were similar in nutrient content to commercial feeds so that it there was value to including a commercial ration as a treatement in these experiments. The rations tested should therefore be seen as 'developmental diets', intended to guide future project activities. The rations are not suitable for field application.

166. A second objective of the feeding trials was to seek a suitable oilseed cake to complement the SP and CAS-based rations. Root crops are low in CP so that root crops need to be combined with a high protein source such as oilseed cakes, fishmeal or blood meal. The use of fishmeal is costly and many believe to be environmentally unsustainable in the long term. For sustainability, local

oilmilling by-products need to be used in livestock rations. CSC was recognised during the prefeasibilty study (paragraph 60) to be an important feed ingredient of the region due to its low cost and high content of CP, which is also of high amino-acid digestibility. Although CSC contains toxic principles (paragraph 141) NRI conducted a great deal of research on seeking methods for its detoxification, without which it would be impossible to consider high dietary inclusion rates, particularly for laying hens. Treatments F-H of the broiler trial and treatment G of the layer trial were included to obtain some preliminary data of the potential for using SP and CAS in combination with this 'problem' feed to keep open the option that its use may still be viable in the production systems of the target poultry producers. As can be noted from Appendix 16.6, Tables 1-6, the inclusion of CSC with or without ferrous sulphate heptahydrate (FSH) treatment reduced the cost of the ration considerably. It was expected that the knowledge gained on the financial potentials of these particular dietary treatments would lead to the design of rations that were appropriate to the socio-economic circumstances of resource-poor farmers.

167. Several other points concerning the feed composition should be noted. Although in the project region, vitamins and minerals are periodically added to the water supply, it was decided to add the premix (Appendix 16.6, Table 1 for composition) to the feeds (for only these trials) to order to obtain a more homogenous distribution so as to increase the probability of each chicken receiving its fair allocation of these micronutrient. This would reduce the variability in poultry performance so that the any genuine differences between varieties would become amplified. Second, the FSH-treated diets were allowed a slightly higher phosphorus content to overcome any reduction in phosphorus that might occur in the intestine of hens from the formation of insoluble iron phosphates (Panigrahi, 1996b). Third, for broilers different diets were formulated for the starter (0-4 weeks) and finisher (4-8 weeks) stages, in order to match dietary nutrients closely to the requirements of chicks as they grow older. However, it was decided that this approach would not be optimal for rations to be used subsequently in the project because of the high cost of CP associated with root crop based starter rations which generally contain 23-24 per cent. A single ration for the entire production cycle of about 21 per cent crude protein was considered optimal to meet the resources and constraints of the target poultry producers.

### 11.5.7.1.3. *Processing of feeds for experimental diets*

168. The SP and CAS were shredded using the J3 plate of the TRS food processor. The SP varieties were processed in rotation in order to prevent any one variety rotting more than the other two (rotting is quick with SP and is an additional resource management consideration underlying the development of the proposed technology of gritting and drying). The processing was done in two shifts, one between 7 and 10 am and the other between 12 and 2 in order to allow the TRS food processer to cool down. Each shift processed 150 kg of tubers.Sun-drying was over within 7 hours for the morning shift produced material, but that produced in the afternoon shift needed to be brought indoors to be spread out in the sun the following day. The sun-dried shreds from both SP and CAS were ground and then mixed with the other ingredients of all layer rations. Ground SP and CAS were also used for all the broiler rations except for two of the treatments (Diets F and H) for which it was decided to test SP n the shred form (that is without grinding). Since these two treatments were not part of the main objective of the experiment, it was considered useful to obtain some early indications of the potential for using gritted tubers and roots for direct feeding to chicks.

169. The free gossypol content of local CSC was not known at the time of the trial, but was assumed to be around 500 mg/kg based on previous CSC samples analysed by IRZV researchers. For laying hens, iron treatment was conducted at a 4:1 weight ration of iron to free gossypol assumed to be present. This represented 0.25% of FSH. Based on previous NRI studies (Panigrahi, 1992), the following procedure was adopted for treating CSC: 250 g of FSH was dissolved in 1 litre of water and add very gradually to 25 kg of CSC in a plastic bag. The mixture was shaken vigorously for 20 minutes and the bag left open in the sun for a further 2 hours to allow evaporation of excess water. This method was used because MRS did not have a small feed

mixer to mix small quantities of feeds with liquid materials. For broilers, treatment of CSC with FSH was carried out as for layers except that only 63 g of FSH, representing a 1:1 ratio of iron:free gossypol was used.

170. Since the egg discolouration problem is not of concern with broilers, and FSH is an additional cost and not generally available in the rural areas, it was considered that the real benefits of treating the CSC needed to be determined under field conditions of prices additional treatments (Diets F and H) were included in the broiler trial to determine the benefits of treating CSC with FSH on broiler production.

### 11.5.7.1.4. *Broiler chick feeding trial facilities and data collection*

171. The Tuber and Root Variety Evaluation Broiler Trial 1 was begun in April 1995. It was conducted with day-old broiler chicks in a open-sided poultry house that allowed ventillation; however, draught was excluded form the pens during the first 3 weeks of the feeding trial (brooding phase). Five hundred and sixty broiler chicks were , obtained from Societe Des Provenderies du Cameroun (SDP) in Bafoussam (Map 2). Seventy chicks were used per dietary treatment, arranged in 5 replicates of 14 chicks. Since it is difficult to determine the breed of broilers with certainty, and the chicks supplied unsexed, 5 replicates per treatment were used instead of 4 that is normally considered sufficient for statistical validity. Birds will be fed the experimental diets *ad libitum*.

172. Round 'enclosures' (brooding guards to keep young chicks warm) of 2 m diameter and 2 feet height were constructed using plywood. Each 'enclosure' was partitioned into two semi-circled experimental units ('pens'), each unit being provided with a feeder and a drinker. One block (area of poultry house) contained 4 of these round 'enclosures', that is 8 experimental units, to permit a complete randomised block design to be used within the 5 blocks. However, since there were two blocks on the right side of the poultry house (Side East) and two blocks on the left side (Side West) the experiment is of an incomplete randomised block design. Dietary treatments were randomly allocated within blocks but each block contained each of the 8 treatments. The position of the 'sides', blocks, 'enclosures' and 'pens' (shown in Diagram 1) were recorded to enable any systematic non-dietary effects to be taken into account in statistical analysis. The lighting regime was 23 hrs during the first week, 20 hrs during day 8 to day 14, and 12 hours of daylight from there on. The temperature varies between 25 to 35$^{o}$C (days) and 18-22$^{o}$C (nights) between March and September. Chicks will be fed the experimental diets *ad libitum*.

173. The following data were recorded: food intakes on a weekly basis, and body weights at 0, 4, and 8 weeks. The efficiency of food utilisation (gain:feed ratio) were calculated for 0-4 and 0-8 weeks. The data were arranged as shown in Table 13 and sent to NRI for statistical analysis.

### 11.5.7.1.5. *Laying hen feeding trial 1 facilities and data collection*

174. The Tuber and Root Variety Evaluation Layer Trial 1 was conducted using 216 Lohmann Brown laying hens, which were obtained as day-olds from SDP (Bafoussam) in July 1994 and reared on deep litter at MRS. Hens were transferred from deep litter to laying hen cages (individually caged) at 18 weeks of age (point of lay) fed on the control maize layer ration. When 196 hens had each laid a minimum of 3 eggs (April 1995) the layer trial was begun using 28 hens per dietary treatment. The lighting regime was natural (12 hrs of daylight). Birds will be fed the experimental diets *ad libitum*.

**Table 14. Arrangement of broiler trial data for statistical analysis at NRI.**

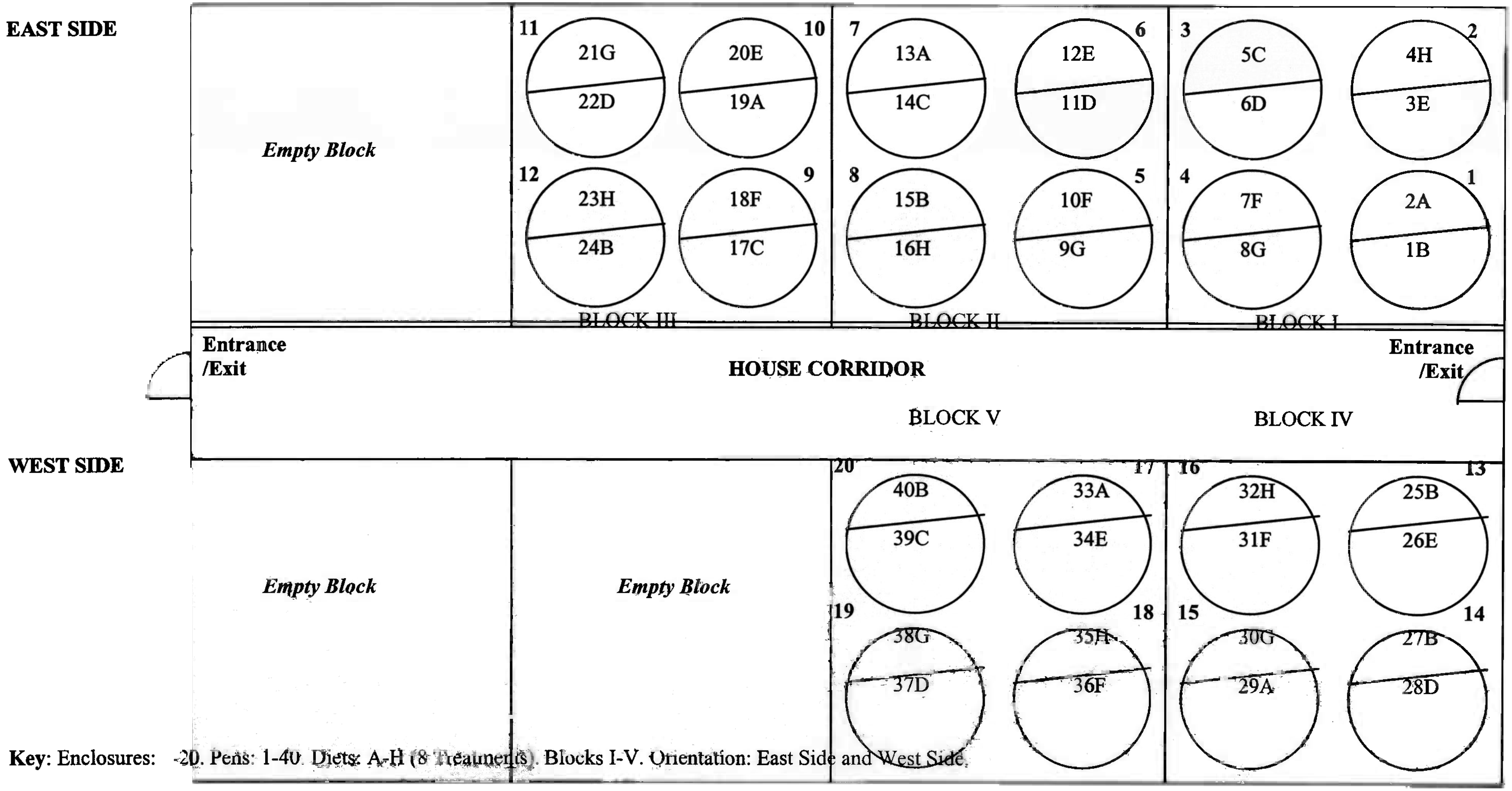
| Dietary Treatment | House Side | House Block | House Enclosure | House Pen | Weight gain Weeks 0-4; 0-8 | Food intake Weeks 0-4; 0-8 | EFU Weeks 0-4; 0-8 |
|---|---|---|---|---|---|---|---|
| B | East | I | 1 | 1 | | | |
| A | East | I | 1 | 2 | | | |
| F | East | I | 1 | 2 | | | |
| | | | | | | | |
| D | East | I | | 2 | | | |
| C | West | V | 20 | 39 | | | |
| B | West | V | 20 | 40 | | | |

175. The laying hen building has open sides to allow ventillation. An incomplete randomised block design was used, with the two sides of the length of the poultry house opposing each other (one facing the window, the other facing the interior of the hen house) representing 'blocks', and there being three tiers of cages in each block. Allocation of birds to cages was such that each treatment was represented in each tier at least 4 times, randomising allocation within this constraint. The position of the blocks, tiers and cages and treatments are shown in Diagram 3.

**Table 15. Arrangement of layer trial data for statistical analysis at NRI.**

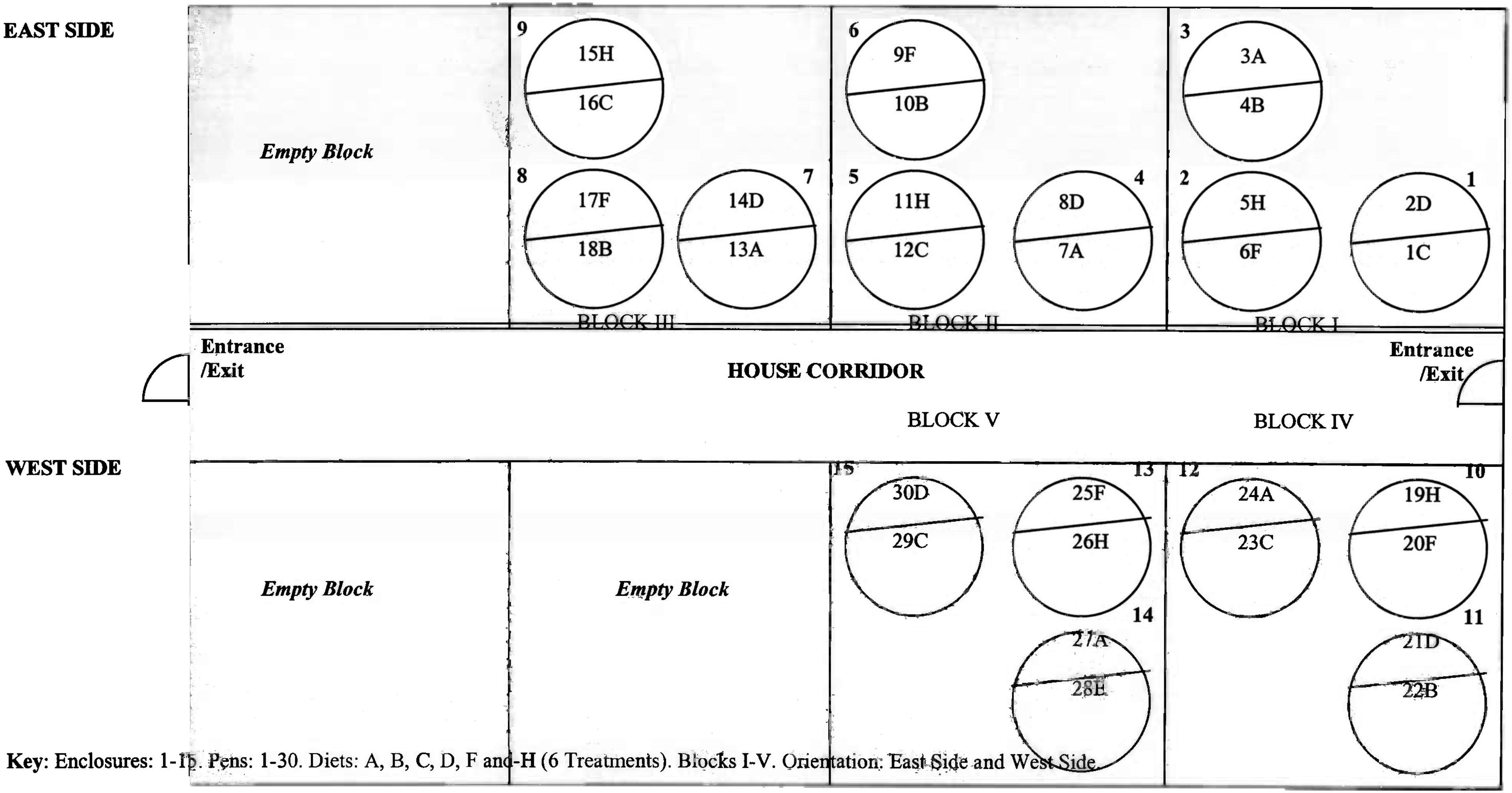
| Dietary treatment | Cage | Block | Tier | Food intake Weeks 1, 2, 3... | Egg no Week No 1, 2, 3... | Egg mass Week No 1, 2, 3..., | Body weight on days 56, 112 |
|---|---|---|---|---|---|---|---|
| 1B | | | | | | | |
| 2C | | | | | | | |
| 3E | | | | | | | |
| | | | | | | | |
| 194A | | | | | | | |
| 195E | | | | | | | |
| 196D | | | | | | | |

**Diagram 1. Treatment randomisation and house orientation in the Tuber and Root Variety Evaluation Broiler Trial 1.**




**Key**: Enclosures: -20. Pens: 1-40. Diets: A-H (8 Treatments). Blocks I-V. Orientation: East Side and West Side.

**Diagram 2. Treatment randomisation and house orientation in the Dried Tuber and Root Shreds Storage Broiler Trial 1.**




**Key**: Enclosures: 1-15. Pens: 1-30. Diets: A, B, C, D, F and H (6 Treatments). Blocks I-V. Orientation: East Side and West Side.

**Diagram 3. Treatment randomisation and cage positioning in on-station Layer Trial 1.**

***Upper Tier*:** **Window Side (East)**

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| | D | C | D | C | F | A | G | C | B | A | D | G | D | E | F | B | C | E | B | A | E | B | G | F | B | A | F | G | A | E | F | G |

***Middle Tier***

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 |
| A | C | E | B | G | F | E | D | C | G | B | F | A | C | G | D | G | F | E | B | F | B | C | A | G | F | D | E | A | E | D | A | C |

***Lower Tier*:**

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 98 | 97 | 96 | 95 | 94 | 93 | 92 | 91 | 90 | 89 | 88 | 87 | 86 | 85 | 84 | 83 | 82 | 81 | 80 | 79 | 78 | 77 | 76 | 75 | 74 | 73 | 72 | 71 | 70 | 69 | 68 | 67 | 66 |
| E | C | F | C | E | B | F | D | C | F | E | B | G | E | D | G | D | A | E | B | A | G | D | B | A | F | C | G | B | F | A | G | D |

***Upper Tier*:** **Aisle Side (West)**

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 130 | 129 | 128 | 127 | 126 | 125 | 124 | 123 | 122 | 121 | 120 | 119 | 118 | 117 | 116 | 115 | 114 | 113 | 112 | 111 | 110 | 109 | 108 | 107 | 106 | 105 | 104 | 103 | 102 | 101 | 100 | 99 |
| | G | B | G | D | B | D | E | C | E | B | G | D | A | F | C | F | D | A | D | F | B | E | B | C | F | C | F | G | A | E | A | C |

***Middle Tier*:**

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 | 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 | 161 | 162 | 163 |
| B | D | C | B | D | E | C | A | G | F | D | C | F | D | A | F | G | E | A | E | B | E | D | A | F | C | B | C | G | A | G | E | G |

***Lower Tier*:**

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 196 | 195 | 194 | 193 | 192 | 191 | 190 | 189 | 188 | 187 | 186 | 185 | 184 | 183 | 182 | 181 | 180 | 179 | 178 | 177 | 176 | 175 | 174 | 173 | 172 | 171 | 170 | 169 | 168 | 167 | 166 | 165 | 164 |
| G | C | D | G | F | C | E | G | F | A | C | D | A | C | D | B | E | D | E | A | B | G | C | E | B | F | B | D | A | F | A | B | E |

176. The following data were recorded: weekly food intakes, and daily egg production (the number of eggs laid and weight of each egg laid). The hens were weighed at 0, 8 and 16 weeks. Soft-shelled and broken eggs found on cage tray were recorded. From the data the efficiency of lay was calculated in terms of (a) the number of eggs laid/kg feed consumed, and (b) the mass of eggs laid/kg feed consumed. The significance of these results were assessed in relation to the change in body weight between 0-8 weeks and 0-16 weeks. (It should be noted that because of insufficient material, the treatment C (using SP variety TIB2) was terminated at 8 weeks, but these hens will be left in their positions untill the end of the 16 week feeding trial in order to prevent disrupting the other experimental birds. The raw data were arranged as shown in Table 14 and sent to NRI for statistical analysis.

### 11.5.7.2. *Broiler trial 2 to determine the feeding value of stored sun-dried tuber and root shreds*

177. The broiler trial was repeated in August 1995 using Diets A, B, C, D, to determine the effects of storing the maize, and shredded and dried SP and CAS (sweet potato TIB1, 1112, and cassava white) under identical conditions (indoors in PVC bags, without any insecticide). Treatments F and H were also included in this storage trial for a different reason. These were tested in the shred form in the first trial but cause severe difficulties of food intake and digestibility. It was, therefore, necessary to test these treatments in in the ground (mash) form to ascertain their feeding value relative to each other and with the major treatments used in the first trial, including most importantly the maize-based control ration. The procedure for the trial was as for the first trial, except that there were 6 replicates of 14 chicks per treatment group randomly allocated (Diagram 2) and due to limitation of raw materials the trial could only be conducted for a 4-week duration using the broiler starter ration.

### 11.5.7.3. *Factors affecting interpretation of data from on-station broiler 1 and 2 and layer 1 feeding trials*

178. Before examining the results it is necessary to note that three problems were encountered in implementing the feeding trials. First, although a local supplier had assured a supply of synthetic lysine for the feeding trials project staff were let down at the very last minute. Lysine could not be found in the major cities of Yaounde and Doaula either. Thus, although synthetic methionine were added to diets which needed it lysine was not added. The rations could not be reformulated as all other ingredients had already been purchased and some rations had been mixed. The result was that the lysine content of the diets with CSC became especially low, and makes interpretation of the effects of CSC difficult, in particular for the broiler trials which required high levels of synthetic lysine.

179. Second, as mentioned earlier (paragraph 161-165) the approach adopted entailed the use of nutritionally-balanced rations but these was not perfectly achieved (see '*as intended*' versus '*as achieved*' figures in Appendix 16.6, Tables 2, 4 and 6) because lack of time to conduct determnine the nutrient content of the feed raw materials led to excessive reliance being placed on '*book values*' of the composition of local feeds. The calcium content of rations were particularly low, the error subsequently traced to the following raw materials whose actual and assumed values were (in %): fishmeal 4.42 instead of 5.11; maize 0.01 instead of 0.02; and SP 0.08-0.10 instead of 0.12-0.17, respectively. CPs of diets were also lower than intended, due primarily to underestimating the CP content of the maize and SP. It had been assumed that the CP content of SP would not vary greatly between years so that the values analysed for tubers in 1994 were used in ration formulation. However, on subsequent analysis, the values for the 1995 samples were much lower, as follows (figures in percentages with 1994 figures in brackets): SP TIB1 - 4.12 (8.11), SP TIB2 - 5.40 (6.99) and SP 1112 - 4.87 (5.58). This variability might be due to agronomic factors such as differences in fertiliser application or point-of-harvest, or some other factor under which crops were cultivated in the two years. The lysine content of SP were estimated by taking an average of 10 previously

analysed results obtained for different cultivars at NRI, not the values of the varieties used in the feeding trials. The combination of lower calcium and lower protein could explain the generally lower levels of performance that were obtained in the egg production trial than we might have been expecting. Originally, carcass analysis was planned in which samples of chickens and eggs were to be taken, oven-dried and analysed at NRI for gross energy, fat and nitrogen determination. However, because of the nutrient imbalances, carcass analysis was aborted. as results could not now be interpreted with reliability.

180. Third, a different problem arose when it was decided to test the effects of SP for two of the treatments in the broiler trial (Diets F and H) in the shred form, that is without further grinding. Day-old chicks performed poorly on the shreds, as chicks had difficulty consuming the long shreds. It should be noted that the NRI Phase 2 Trail 1 was conducted with crumbed TRS J3 plate-produced shreds and with 5 d-old chicks which could easily consume it. However, even in that trial examination of the excreta showed that most of the crumbed shreds were passing through the gastro-intestinal tract undigested. In view of these results it was decided to include Treatments F and H in the Tuber and Root Storage trial

### 11.5.7.4. *Results of broiler trials 1 and 2*

181. The results of the broiler feeding trials 1 and 2 are summarised in Table 15. Notwithstanding the nutrient imbalances discussed above, the results of the Tuber and Root Variety Evaluation Broiler Trial 1 showed that SP 1112 had a higher feeding value than SP TIB1 and CAS White had a higher potential as a feed than CAS Red. These findings were consistent with those using grits in the NRI Phase 2 Trial 1. With respect to maize controls, 0-8 week weight gains were 13.5 per cent lower with SP 1112 but only 4.5 per cent lower with the CAS White, with the latter showing the same profitability as the maize controls when results are expressed in terms of weight gain per FCFA spent on feed. Ignoring Treatments F and H for aforementioned reasons, it was of interest to note that whilst growth rate with Treatment G was only 1.43 kg compared with 2.08 kg for controls, it was not unacceptably low and, of major importance for the planning of the project, weight gain per FCFA spent on feed was 2.83 g compared with 2.22 g for the maize based ration, that is it was 27.5 per cent better with the CAS-CSCFe diet. The lower weight gain may be attributed to (a) the low lysine content of the diet arising from the omission of synthetic lysine (paragraph 176), and/or (b) FSH treatment of CSC may have had a deleterious effect on feed palatability. A particular reason for suggesting the latter was the observation that the utilisation of this ration appeared to increase with the length of the feeding period: weight gain up to four weeks was 60 per cent lower than controls but at 8 weeks it was only 31 per cent lower than controls, indicating that chicks were gradually adapting to the ration to exhibit compensatory growth.

182. The Dried Tuber and Root Shred Storage Broiler Trial 2 confirmed the relative differences in the feeding values of SP TIB1, SP TIB2 and CAS White and maize, relative to each other, and provided no indication for any major reduction in the nutritional value of stored tuber and root shreds (comparing the 0-4 week data from Broiler Trials 1 and 2). For Treatments F and H, it shows conclusively that FSH treatment of CSC produced an adverse effect on the utilisation of CSC-based rations. Significantly, for Treatment H the weight gain was lower than the corresponding SPTIB1 ration without CSC (due probably to the lower lysine content of the former) weight gain per FCFA expended on broiler feeds was 3.53 g compared with 2.72 for a standard maize-based ration.

183. Taken together, the overall results of these two broiler feeding trials confirmed that the basic project proposition of developing SP and CAS based rations with a considerable replacement of maize was technically and financially feasible, particularly if CSC (not treated with FSH) was included as the complementary protein source in the ration.

### 11.5.7.5. *Results of layer trial 1*

184. The results of the Tuber and Root Variety Evaluation Layer Trial 1 are shown in Tables 16 and 17. The three varieties of SP gave similar egg production rates as the maize-based control diet whilst two CAS varieties gave significantly higher production rates than the controls. Among the SP varieties SP 1112 yielded the best results in terms of egg production, but among the two CAS varieties there were no significant differences. When examining the efficiency of lay, the number and mass of eggs laid per kg feed consumed were significantly better for the SP and CAS-based rations than for the maize-controls, primarily due to high food intakes associated with the latter. The excess food intake in the maize controls was laid down as body fat, as indicated by the figures for the change in body weights of hens. Significantly, compared with the maize controls, the profitability of production was approximately 15 per cent higher for the SP 1112- and 27 per cent higher for the CAS White ration. Thus, notwithstanding the differences in the nutrient content of the rations, the results indicated that the basic project proposition of replacing maize with tubers and roots was technically possible and financially viable.

185. Compared with the performance of hens fed on the non-CSC CAS White-based diet (Treatment F), hens fed the corresponding iron-treated CSC-based diet (Treatment G) had significantly lower food intakes and egg production, and lost body weight. There were not significant differences in the quality of eggs produced in the two groups. It is not clear what might have happened if a treatment was included in which the CSC was not iron-treated, but previous NRI studies have shown that at the 25 per cent dietary inclusion rate mottlings and discoulourations would almost certainly take. Significantly, Treatment G was the most profitable group in terms of egg production per FCFA spent on feed, being 41 per cent better than in the control maize group. Thus, overall the results of the layer trial showed that there was considerable potential for developing SP and CAS-based laying hen rations for the project region, although much thought was required on whether CSC should be included and if so whether it should be treated with ferrous sulphate.

186. It was noteworthy that egg production was low generally for the age of the birds. It seems reasonable to speculate that this was caused by the lower calcium content of the rations caused by reliance placed on '*book values*' of composition (paragraph 177). However, it is also possible that the quality of the batch of hens received from the hatchery was not good.

**Table 16. Performance of chicks in the Tuber and Root Variety Evaluation and Dried Shred Storage Broiler feeding trials on-station.**

| Dietary treatments | A Control maize | B SP TIB1 | C SP 1112 | D CAS White | E CAS Red | F SPTIB1-CSC/Fe | G CAS White-CSC/Fe | H SPTIB1-CSC | SEM | Significance of diet P (=or <) |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Tuber and Root Variety Evaluation Broiler Trial 1*[1]:** | | | | | | | | | | |
| Weight gain 0-4 weeks (g) | $835^{a}$ | $642^{b}$ | $639^{b}$ | $776^{a}$ | $753^{a}$ | $299^{c}$ | $339^{c}$ | $294^{c}$ | 35.2 | 0.0001 |
| Food intake 0-4 weeks (g) | $1359^{a}$ | $1220^{b}$ | $1182^{b}$ | $1176^{b}$ | $1275^{ab}$ | $714^{c}$ | $827^{c}$ | $714^{c}$ | 44.9 | 0.0001 |
| EFU 0-4 weeks | $0.61^{ab}$ | $0.53^{b}$ | $0.54^{b}$ | $0.66^{a}$ | $0.59^{ab}$ | $0.42^{c}$ | $0.42^{c}$ | $0.42^{c}$ | 0.031 | 0.0001 |
| Weight gain/FCFAon feed (g): | 2.51 | 2.21 | 2.20 | 2.52 | 2.25 | 2.23 | 2.26 | 2.28 | | |
| Weight gain 0-8 weeks (g) | $2080^{a}$ | $1575^{c}$ | $1801^{b}$ | $1987^{a}$ | $1797^{b}$ | $942^{d}$ | $1433^{c}$ | $813^{d}$ | 51.7 | 0.0001 |
| Food intake 0-8 weeks (g) | $4312^{a}$ | $4009^{b}$ | $4021^{b}$ | $3985^{b}$ | $4033^{ab}$ | $2787^{d}$ | $3103^{c}$ | $2873^{cd}$ | 100.8 | 0.0001 |
| EFU 0-8 weeks | $0.44^{ab}$ | $0.37^{d}$ | $0.41^{c}$ | $0.45^{a}$ | $0.41^{bc}$ | $0.29^{e}$ | $0.40^{c}$ | $0.26^{f}$ | 0.011 | 0.0001 |
| Weight gain/FCFAon feed (g): | 2.22 | 1.80 | 1.97 | 2.21 | 1.89 | 2.01 | 2.83 | 1.81 | | |
| ***Dried Tuber and Root Storage Broiler Trial 2*[2]:** | | | | | | | | | | |
| Weight gain 0-4 weeks (g) | $930^{a}$ | $705^{b}$ | $761^{b}$ | $757^{b}$ | | $432^{c}$ | | $609^{d}$ | 27.4 | 0.0001 |
| Food intake 0-4 weeks (g/d) | $50.6^{a}$ | $43.3^{c}$ | $45.9^{b}$ | $46.5^{b}$ | | $34.4^{d}$ | | $33.2^{d}$ | 0.86 | 0.0001 |
| EFU 0-4 weeks | $0.66^{a}$ | $0.58^{c}$ | $0.59^{bc}$ | $0.58^{c}$ | | $0.45^{d}$ | | $0.65^{ab}$ | 0.021 | 0.0001 |
| Weight gain/FCFA on feed (g): | 2.72 | 2.42 | 2.41 | 2.21 | | 2.39 | | 3.53 | | |

***Notes***: EFU - Efficiency of food utilisation as weight gain: food intake ratio. Least square means are shown after adjusting for Block and Enclosure effects. SEM - pooled standard error of means. Values in the same horizontal line with different superscripts are significantly different ($P<0.05$); residual degrees of freedom Feeding Trial 1, 29. Feeding trial 2, 21. SP and CAS grits were produced between January and February 1995. 1. Experiment started on April 1995. 2. Experiment started on 8th August 1995.

**Table 17. Performance of hens fed tuber and root-based diets during 0-8 weeks of the first on-station layer feeding trial.**

| Dietary treatments | A Control maize | B SP TIB1 | C SP TIB2 | D SP 1112 | E CAS White | F CAS Red | G CAS White-CSC/Fe | SEM | Significance of diet (P=or <) |
|---|---|---|---|---|---|---|---|---|---|
| Food intake (g/hen d) | 114.4[a] | 104.1[bc] | 99.2[bc] | 107.8[b] | 100.3[bc] | 101.1[cd] | 97.7[d] | 3.45 | 0.0001 |
| Change in body weight (g) | 64[a] | -57[cd] | -19[bcd] | -19[bcd] | 59[ab] | 111[a] | 24[d] | 28.3 | 0.0001 |
| Number of eggs laid/d | 0.57[b] | 0.61[b] | 0.59[b] | 0.65[ab] | 0.69[a] | 0.68[a] | 0.60[c] | 0.031 | 0.0001 |
| Egg output (g eggs/hen d) | 32.5[b] | 34.8[b] | 33.6[b] | 38.3[ab] | 39.8[a] | 39.8[a] | 32.6[c] | 1.15 | 0.0001 |
| Number of eggs/10 kg food | 50[a] | 61[b] | 60[b] | 63[b] | 68[c] | 68[c] | 63[ab] | 2.10 | 0.0001 |
| Gms eggs/kg food | 288[a] | 346[bc] | 340[bc] | 367[c] | 392[d] | 395[d] | 345[ab] | 10.1 | 0.0001 |
| Gms eggs/1000 FCFA feed cost | 1376 | 1663 | 1589 | 1723 | 1842 | 1836 | 2132 | | |
| Number of eggs/10000 FCFA | 241 | 294 | 280 | 295 | 319 | 315 | 390 | | |

*Notes*: Least square means are shown after adjusting for Block and Tier effects. SEM - pooled standard error of meals. Values in the same horizontal line with different superscripts are significantly different (P<0.05). residual degrees of freedom 184.

**Table 18. Performance of hens fed tuber and root-based diets during 0-16 weeks of the first on-station layer trial.**

| Dietary treatments | A Control maize | B SP TIB1 | D SP 1112 | E CAS White | F CAS Red | G CAS White-CSC/Fe | SEM | Significance of diet (P=or <) |
|---|---|---|---|---|---|---|---|---|
| Food intake (g/hen d) | $119.1^{a}$ | $104.5^{bc}$ | $108.6^{b}$ | $105.4^{bc}$ | $101.4^{cd}$ | $95.9^{d}$ | 2.45 | 0.0001 |
| Change in body weight (g) | $84^{a}$ | $-67^{cd}$ | $-52^{bcd}$ | $30^{ab}$ | $87^{a}$ | $-87^{d}$ | 32.3 | 0.0001 |
| Number of eggs laid/d | $0.62^{b}$ | $0.63^{b}$ | $0.67^{ab}$ | $0.72^{a}$ | $0.70^{a}$ | $0.55^{c}$ | 0.023 | 0.0001 |
| Egg output (g eggs/hen d) | $36.3^{b}$ | $36.1^{b}$ | $39.5^{ab}$ | $42.2^{a}$ | $41.3^{a}$ | $30.6^{c}$ | 1.24 | 0.0001 |
| Number of eggs/10kg food | $53^{a}$ | $61^{b}$ | $62^{b}$ | $69^{c}$ | $69^{c}$ | $58^{ab}$ | 2.0 | 0.0001 |
| Gms eggs/kg food | $309^{a}$ | $346^{bc}$ | $364^{c}$ | $402^{d}$ | $408^{d}$ | $322^{ab}$ | 9.8 | 0.0001 |
| Gms eggs/1000 FCFA feed cost | 1478 | 1662 | 1712 | 1898 | 1887 | 1987 | | |
| Number of eggs/10000 FCFA | 254 | 291 | 291 | 322 | 322 | 359 | | |

*Notes*: Least square means are shown after adjusting for Block and Tier effects. SEM - pooled standard error of meals. Values in the same horizontal line with different superscripts are significantly different (P<0.05). residual degrees of freedom 184. Treatment C discontinued after 8 weeks due to insuffient SP TIB2.

**11.5.7.6.** ***Implications of the results of the first on-station feeding trials for the design of on-farm rations***

187. Several points emerged from these feeding trials that have a bearing on the development of poultry rations of optimal and sustainable rations for the resource-poor rural poultry producers, who are generally characterised by having spare labour but lacking cash. The plane of nutrition needs to be adjusted to the resources and constraints of farmers, so that the broiler production is a intermediate-intensity system (that is not as productive as large-scale commercial systems) the intensity being dependent on what farmers can afford. It is necessary to understand the nutritional implications of minimising cash outlay on feeds to the level that the farmer can afford and then developing a nutrient balance in the ration in accordance with feed availability that maximise productivity.

**11.5.7.6.1.** ***Plane of nutrition: the broiler starter-finisher ration concept***

188. It was inevitable that the broiler rations would be nutrient sub-maximal in terms of the dietary requirements of chicks The difficulty in obtaining synthetic amino acids (lysine and methionine) nd their high cost excluded their use in rations for the projects target group. It was also decided not to use any any vegetable oils due to their high cost as well as for the facts that oils can become rancid, and the target group will not find it easy to mix it with other feed ingredients. These omissions made it impossible to develop the normal broiler rations of 1.25 per cent lysine (starter) and up to 13.10 MJ/kg AME (finisher) phase. As a consequence, the benefits of using a high CP content (23-24 per cent) in the starter ration became questionable, whilst there was now uncertainty of what would be the optimal balance of lysine, CP and AME for maximal growth performance (as there is no reliable guidelines in the literature for such circumstances). Further, if a lower than 23-24 per cent CP was used in the starter phase the concept of starter and finisher rations was considered to become redundant, so that a single ration was developed for the 0-8 week growth period.

189. Another consideration for adopting a single ration broiler feeding system was that a change of ration in the middle of a production cycle (starter 0-4 weeks and finisher 4-8 weeks) could be a disincentive to many small-scale producers because of the practical complications it creates. Farmers need to purchase two types of feeds and keep these feeds separate with appropriate labelling. They then need to monitor the age of the chicks as they grow so that the feed may be changed on a particular day. A change of feed in this manner could also lead to wastage of the starter feed. The feeding system would only work if a feed management system is maintained. This will require a small feed store area that resource-poor producers can ill afford. It was, therefore, considered that the target group should prefer to deal with just one ration for practical reasons.

190. Without any literature guidelines (strategic research on this aspect of poultry nutrition is needed to assist the development of rations for resource poor farmers), the project considered that a CP level of between the starter and the finisher may be suitable as it could enable the compensatory growth phenomenon of broilers to be used to advantage (Yu and Robinson, 1992). This is based on the supposition that chicks would fall behind those on a starter-finisher regime during the starter phase may catch up with the others by the end of 8-week feeding period. The formulation technique adopted was selecting the least cost ration incorporating a minimum of 50 per cent of SP or CAS in a diet of 22 per cent CP, 12.40-12.65 MJ AME/kg, 1.00 per cent calcium, 0.7-0.85 per cent phosphorus, 0.4-0.5 per cent salt, 0.85-0.95 per cent methionine plus cystine and as high a lysine content as can be achieved up to 1.10 without the use of synthetic amino acids.

191. It was, however, recognised that with sub-maximal diets chicks may cause more feed spillage in their search for the nutrients required. Close attention, therefore, needs to the paid to the design of the feed hoppers to reduce feed spillage which will be a cost to resource-poor farmers. This may be achieved by restricting head movement within the hoppers by the use of partitions or by better shape of the edges of the hopper. Alternatively, spilt food may be collected and put back into the hopper,

but this would involve additional labour. Finally, it may be argued that no measures are necessary since chickens will consume subsequent feed from the floor.

### 11.5.7.6.2. *Age of chicks to be given tuber and root-based rations*

192. The reason for varying the age at which broiler chicks were presented with SP and CAS-based feeds in the NRI Phase 2 adaptive research (Section 11.4.3) was the finding from poultry farm characterisation study that in the western highlands of Cameroon day-old chicks are highly valuable, representing 25 per cent of the cost of poultry production by resource-poor producers. It was considered that farmers may, therefore, be reluctant to risk giving a unconventional feeds to chicks when they are most vulnerable to stress due to climatic and anti-nutritional factors in feeds. This was also the reason that the on-station tuber and root grit feeding trials (Section 11.5.10.2.1) were also conducted with 9-day old chicks instead of day-olds. However, in view of the finding from the two on-station broiler trials that day-old chicks performed well with ground SP and CAS diets (there was no treatment-related mortality) it was decided that it was feasible to present test feeds to day-old chicks in the on-farm testing stage provided that chicks received adequate brooding (paragraph 132). As a result of these deliberations, it was decided to conduct the first on-farm feeding trials (in which mash feeds were to be used) with day-old chicks rather older birds. Introducing feeds from day-old would be more appropriate for small-scale producers who would otherwise need to purchase some commercial feed to start their chicks on. A feeding regime requiring a switch from one ration to another could cause additional work and confusion for some resource-poor poultry producers and was one of the reasons that dual starter-finisher concept for broilers was also abandoned (paragraph 165). Thus, developing ration technology that can be fed to day-old chicks was considered to be a major objective of the project and which applies as much to rations presented as mash as to rations in which SP and CAS are included as grits.

### 11.5.7.6.3. *Development of feed composition chart for project field site*

193. In view of the proven inadequacy of '*book values*' of composition of feeds for project implementation (paragraphs 176-177), the nutritional analysis conducted in NRI (paragraph 124) was extended to the determination of the amino acid composition. Whereas the AME content of all feeds were estimated according to the European Table for metabolisable energy value of feeds (EEC, 1986), the correct approach is to use the real AME values as determined for each locally available feed ingredient used as complementary feeds, by conducting metabolism studies under controlled environment feeding trials. The NRI Phase 2 studies were extended to review the AME values of local feeds by determining the gross energy values of all diets and excreta voided by chicks. The calcium content of broiler and layer diets were particularly low so that the local oyster shells, bone meal, and other raw materials were analysed for this mineral. Based on these comprehensive analysis, a feed composition chart that would allow least-cost poultry ration formulation in the region of the project site was constructed (Appendix 16.5), and formed the basis of the development of rations for all subsequent project feeding trials. This Chart will, however, be useful to IRZV in their future feed developmental work and will also enable other local government agricultural extension agencies.

### 11.5.7.6.4. *Selection of sweet potato and cassava varieties*

194. Since SP 1112 gave the best production of all SP varieties tested in both broilers and layers, it was decided to cultivate this variety on MRS fields for the on-farm trials. CAS White was selected for use as this variety had a higher nutritional value than CAS Red in the tuber and root cariety evaluation feeding trials.

### 11.5.7.6.5. *Use of cottonseed cake with or without iron treatment*

195. NRI's previous studies have shown that there are minor beneficial effects on broiler performance of treating CSC with crystalline ferrous sulphate (unpublished). The Tuber and Root Storage Broiler Trials 1 and 2, however, showed that there were deleterious effects of treating CSC with FSH on weight gain and efficiency, although it was not clear whether this was simply a palatability problem or a toxicological problem. For laying hens the performance of hens fed the iron-treated CSC was significantly lower than controls (Tables 17 and 18).

196. Whilst researchers agreed that CSC must be used in the ration the question, because it was considerably cheaper than soyabean meal which may be imported into the country (Appendix 16.3, Table 26). However, how much CSC should be used and whether it should be treated with ferrous sulphate were vexing questions. It appears that the NRI suggestion of solution treatment was not successful in the field, particularly for laying hens (Panigrahi, 1992b). However, it is also possible that the technology did not work in the field due to inadequate diet mixing. Since MRS did not have a small mixer to mix experimental diets, plastic bags were used, which could have led to different reactions taking place in the feed than found in NRI studies. Further, it was not clear whether addition of FSH in the crystalline form would also have given better, similar or even worse results in the field. Thus, much uncertainty was introduced on the ration formulation strategy to be pursued in project development. Further research was considered necessary to test a few combinations of rations with different methods of FSH treatment before any firm conlusions could be drawn. However, there were no funds, and more importantly time, to conduct this work in the present project.

197. In view of these considerations, different approach was adopted for broilers and layers. For broilers, the beneficial effects from NRI studies were minor so that it was decided to use CSC at up to 25 per cent inclusion rate without any iron treatment. A more important reason for not using iron salts was that in common with synthetic amino acids (paragraph 186) these are not generally available in the rural areas, and treatment of the CSC was likely to create confusion in the minds of users, which could potentially lead to disastrous results if too high a quantity was inadvertently used. Further, researchers considered that there were no serious meat quality problems in relation to the presence of gossypol in chicken meat to consider, since the CSC variety locally available was low in gossypol. It should be noted that analysis completed in 1996 showed that the free gossypol content 8 samples of CSC taken from different sources in Cameroon contained 715, 715, 880, 980, 1130, 1250, 1300 and 1380 mg/kg; but MRS researchers believe that the local expeller CSC from Sodccoton mill in Kaele contains only around 500 mg/kg of gossypol and is consequently exported to France because of its high quality.

198. However, for layers a different set of considerations apply. Will egg discolourations take place and will egg production decline, if CSC was limited to below the 15 per cent of the diet in the on-farm rations? If there was a serious danger of the eggs becoming unmarketable because of discolourations, then addition of some FSH would be desirable, but the question then would be whether to use a lower than the generally recommended concentration of a 4:1 weight ratio of iron:gossypol, and whether it should be added in crystalline form or in solution. Other questions were will there be long term adverse effects of feeding CSC at this level on egg production and health of birds?. At more than 25 per cent inclusion rate researchers were reluctant to use CSC without iron treatment, particularly since treatment with FSH in the first on-station feeding trial had depressed production but this was still most profitable ration. Pending further strategic research to address the technical issues identified above, the only practical option was, therefore, to limit the CSC inclusion rate to about half the inclusion rate to see if this will prevent the egg discolouration problems whilst ensuring a high level of egg production. Lack of access to FSH for peasant poultry production and practical complications related to feed mixing supported this approach. It was, however, essential to test these first in an on-station trial before deciding whether the rations would be suitable for transfer to resource-poor farmers. Thus, in the on-station testing of first on-farm layer trial it was decided to use untreated CSC at a maximum of 13 per cent inclusion rate, using least cost diet formulation.

### 11.5.7.7. *First tentative rations designed for target beneficiaries*

199. The project objective was to design SP-based and CAS-based, low-in-cereal or cereal-free poultry rations for the target beneficiaries in the project site region. Since the ultimate test of the success of the project would be the relative profitability of these rations with current farmer practices, at this stage the project needed to develop and test one of each type of these rations and to compare the performance of chickens fed on these rations with the best commercial feeds (as indicated by the price) that was sold in the project site region. The commercial ration selected wa that made by the company Elevage Promotion Afrique (EPA). Ultimately, the success of the project would be based on testing (and demonstrating) the rations under farmer conditions in their premises. Thus, the treatments for the next stage of feeding trials were:

***Broiler:***
A. Ration with SP 1112 (cereal-free) for 0-8 weeks
B. Ration with CAS White (cereal-free) for 0-8 weeks
C. Commercial ration - EPA Starter for 0-4 weeks, followed Finisher for 4-8 weeks

***Layer***:
A. Treatment ration with SP 1112 (cereal-free)
B. Treatment ration with CAS White (very low in cereal)
C. Commercial ration - EPA Layer.

200. Apart from the nutritional implications arising from the first series of on-station broiler and layer trials discussed in the previous section (paragraphs 164-175) the findings from the NRI Phase 2 Part 1 on local agricultural feed resources (paragraphs 94-99) needed to be considered for incorporation in the SP and CAS-based rations. Besides SP and CAS, oilseed byproducts such as PPS and WPK were considered to be of considerable importance as potential feed resources for small-scale rural poultry production and used in the rations. At a more general level, it is suggested that cereal milling by-products (local rice bran), rural slaughter house by-products (local blood and bone meals), brewery by-products (eg brewers dried grains from a brewery in Bafoussam) and products from local mining activities (eg limestone) need to be utilised in rations as far as possible since it not only makes rations cheaper because this reduces the use of materials that have to be imported into the area (such as imported soyabean meal and concentrates), it assists rural development by adding value to the by-products and, as in the case of PPS, the waste products of local small-scale agro processors and industries. Thus, the rations which take account of the resources and constraints of the target poultry producers also become consistent with the wider local agricultural system. The nutritional approach may, therefore, be described as animal nutrition for sustainable livestock development.

201. The third component of the rations for the target beneficiaries is the form of presentation of SP and CAS in the rations. The use of grits of the appropriate dimensions was believed to be important technolgy as it by-passed the grinding process and made savings not only on the cost of feed production, utilisation by chickens of the rations was improved. However, socio-economically optimal technology was not available or even guaranteed in terms of the development of manual griiting machine. Two prototypes had been developed by September 1995 (paragraphs 271-272) but these were the grits produced were too large for day-old chicks although these could be sun-dried within one day. It was, therefore, not appropriate to use grits at this stage. The option of testing their use doing so once a suitable gritting machine was developed was however kept open.

**Table 19. Composition of the first tentative broiler rations designed for target users (% unless otherwise stated).**

| Treatment rations | Sweet potato-based diet (A) | Cassava-based diet (B) | Commercial diet (C) Starter | Commercial diet (C) Finisher |
|---|---|---|---|---|
| ***Ingredients:*** | | | | |
| Fishmeal | 10.185 | 10.431 | | |
| Oyster sea shells | 0.478 | 0.939 | | |
| Bone meal | 0.868 | 0.301 | | |
| Cottonseed cake | 18.368 | 20.294 | | |
| Blood meal | 2.000 | 2.050 | | |
| Salt | 0.142 | 0.105 | | |
| Palm pit sediment | - | 6.000 | | |
| Sweet potato tuber meal - 1112 | 53.663 | - | | |
| Cassava root meal - White | - | 50.000 | | |
| Whole palm kernels | 14.296 | 9.88 | | |
| ***Total*** | 100 | 100 | 100 | 100 |
| ***Ration cost (FCFA/kg)*** | 137.11 | 121.81 | 250 | 230 |
| ***Calculated analysis:*** | | | | |
| Crude protein | 22.00 | 22.00 | 25.5 | 22.5 |
| Metabolisable energy (MJ/kg) | 12.40 | 12.45 | 12.12 | 12.33 |
| Calcium | 1.00 | 1.00 | 1.20 | 1.00 |
| Phosphorus | 0.75 | 0.70 | - | |
| Available phosphorus | - | - | 0.50 | 0.40 |
| Lysine | 1.10 | 1.08 | | |
| Methinine+cystine | 0.93 | 0.93 | | |
| Salt | 0.40 | 0.40 | | |

202. The rations are shown in Tables 18 and 19. The same consideration concerning each ingredient was not applied to the four broiler and layer test rations in order to explore different ration options since the project was still at the exploratory stage in terms of the design of rations for use on the farm. For example, PPS was only included only in the CAS-based broiler ration. However, whole palm kernels were included in each of the four ration because it was very cheap in the rural areas, being sold at 25 FCFA per kg in 1995.

203. The SP and CAS-based diets Treatment Rations A and B were formulated on the basis of nutrient analyses and prices shown in Appendix 16.6. practice in the poultry production systems of the region. However, for AME values were different as the NRI Phase 2 studies had not been completed at the time of the feeding trials It should be mentioned that AME values are always 'guesstimates' and the poultry nutritionist always needs to keep these values under review. The difference in the nature of the rations designed for the target group and the diets used in the first on-station Tuber and Root Variety Evaulation Trials (Appendix 16.7, Tables 1-6) is apparent in the much lower plane of nutrition (see calculated analyses) which makes the rations for the target group (farmer rations) nutrient-sub-maximal (expected to result in lower productivity unless the principles of compensatory growth come into play), and the considerably lower cost (to reduce cash outlay by the farmers). Another difference between the first on-station feeding trials and those planned for on-farm trials is that in the latter vitamins and minerals would be provided in the drinking water, as is the practice in the production systems of the project region.

**Table 20. Composition of the first tentative layer rations designed for target beneficiaries (% unless otherwise stated).**

| Treatment rations | Sweet potato-based diet (A) | Cassava-based diet (B) | Commercial layer diet (C) |
|---|---|---|---|
| ***Ingredients:*** | | | |
| Fishmeal | 9.384 | 9.020 | |
| Oyster sea shells | 8.191 | 8.737 | |
| Bone meal | 1.653 | 1.414 | |
| Cottonseed cake | 11.400 | 13.000 | |
| Blood meal | 1.000 | 1.414 | |
| Salt | 0.142 | 0.146 | |
| Sweet potato tuber meal 1112 | 50.000 | - | |
| Cassava root meal -White | 4.561 | 50.000 | |
| Maize | - | 3.623 | |
| Whole palm kernels | 13.669 | 12.646 | |
| ***Total*** | 100 | 100 | 100 |
| ***Ration cost (FCFA/kg)*** | 129.12 | 115.45 | 200.0 |
| ***Calculated analysis:*** | | | |
| Crude protein | 17.00 | 17.00 | 17.0 |
| Metabolisable energy (MJ/kg) | 11.60 | 11.64 | 11.7 |
| Calcium | 3.80 | 3.90 | 3.60 |
| Phosphorus | 0.75 | 0.73 | - |
| Available phosphorus | - | - | 0.40 |
| Lysine | 0.87 | 0.85 | |
| Methinine+cystine | 0.80 | 0.77 | |
| Salt | 0.40 | 0.40 | |

### 11.5.7.8. *On-station poultry feeding trials to test the first set of tentative on-farm rations*

204. There were three reasons of relevance to project development for which it was necessary to test the above rations in on-station feeding trials before testing them on-farm. First, the on-farm trials were to be left largely under farmer control under the terms of farmer participation so that the data obtained on the productivity and profitability of the rations could not be expected to be very reliable unless a large-scale experimentation was conducted with several replicates of each farmer type. Project funds only permit a limited scale of on-farm trials with no replication. It was, therefore, appropriate to base any recommendations arising from the project outputs on a combination of on-station under researcher control and on-farm trials. Second, pre-testing of rations would leave open the scope for modifying the ration if productivity and profitability were not likely to be sufficient to encourage adoption. Thirdly, researchers needed to develop some confidence in the rations, as the rations developed are specific to the resources and constraints of farmers in the project location, an approach that has not been attempted before with poultry as far as the researchers were aware.

205. For these trials SP 1112 an CAS White were processed through the AS4 plate of the TRS since this was believed to be optimal if the grits produces were to be further ground before being mixed with other ration ingredients. The broiler trial was conducted with day-old chicks (paragraph 169), using eight replicates of 14 chicks each, randomly allocated to the pens, enclosures and blocks, but using only blocks I-IV shown in Figure 2.

206. The layer trial was conducted with the same batch of laying hens used in the first on-station feeding trial, which were now 18 months of age (8 months into lay), and their hen day production rate was around 50 per cent. Ideally, newly laying hens should have been used, but these would have

had to be reared on station from May 1995 to be available for the feeding trial in December. Since chicks were being reared from day-old for transfer to the first on-farm trials that were to take place in January-February 1996, there were no facilities left on MRS to rear another batch of chicks to point-of-lay for on-station tests. Rearing also entails considerable costs in terms of chicks, feeds, veterinary care and labour time for animal husbandry, so that it appeared more reasonable to use the old hens already in cages from the previous experiment. Hens were allocated to diets and cages randomly using 16 hens per treatment, using an incomplete randomised block design to take account the tier effects. Hens were fed the three experimental diets for 8 weeks, and data were recorded as described previously (paragraphs 5-154).

### 11.5.7.9. *Results of the on-station testing of first tentative broiler rations (broiler 3)*

207. The results of the broiler trial are summarised in Table 20. After 4 weeks of feeding, the liveweights of chicks fed on the SP- and CAS-based diets were 46 and 23 per cent lower than those of chicks fed the commercial ration, the figures being 51 and 20 per cent respectively by 8 weeks of feeding. Similarly, food intakes of chicks fed on the SP- and CAS-based diets were 32 and 17 per cent lower than those of chicks fed the commercial ration, the figures being 34 and 17 per cent respectively by 8 weeks of feeding. The efficiency of food utilisation (EFU) during 0-4 weeks of the SP- and CAS-based dietary groups were 21 and 8 per cent lower than for the commercial diet group, the figures being 26 and 12 per cent, respectively, for the 0-8 week period.

208. The lower productivity of chicks fed on the test rations was not unexpected in view of the nutrient sub-maximal rations used, but the scale of the lower productivity was surprising. It was evident that compensatory growth phenomeonon did not take place in the manner expected, possibly because of feed texture. When fed in mash form tubers and roots are very powdery (dusty) so that intakes are also depressed regardless of the nutrient content of the ration. The texture may be ameliorated by the use of vegetable oils which facilitates higher food intakes. This was the reason for allowing in palm oil into these rations in the Tuber and Root Variety Evaluation broiler and layer trials (Appendix 16.6, Tables 1, 3, and 5). It was not used in the present trials primarily because of the high cost. However, other factors that might have contributed to the lower productivity were the coarsely ground nature of WPK (finely ground was used in the NRI Phase 2, Part 1 trials), and the chicks were from a poor batch sent by the hatchery as indicated by the fact that even those fed the control ration could not reach more than 2 kg by eight weeks of feeding.

209. However, small-scale broiler producers rarely keep chickens throughout the year liveweights and efficiencies are not the appropriate criteria for judging the suitability of the ration for onfarm testing. In most situations, chicken begin to be sold in small quantities from 8 weeks of age and the entire batch may not be sold even 4 weeks later. Further, meat chickens are not sold by weight in the project site but by appearance of size. Since feed costs represents 60-65 per cent of the costs of poultry production and the cost of day-old chicks represents 25 per cent (Appendix 16.3, Table 44) when these factors are considered together, the most relevant criteria for guaging the suitability of the rations for transfer to the target group is the cost of feed per kg liveweight gain over the entire production cycle. Assuming all chickens would be sold at 8 weeks, it cost 619 FCFA per kg of feed consumed to produce chickens using the commercial ration, as against 478 FCFA for the SP-based ration and only 360 FCFA for the CAS-based ration. Thus, the savings on cost of broiler meat production were 23 per cent for the SP-based ration and 45 per cent for the CAS-based ration. Thus, notwithstanding the lower productivity in comparison with the best commercial feed sold in the area, the on-station testing showed that both test rations had considerable promise for developing an intermediate-intensity poultry production system that met the needs of the poultry producers in the project region.

210. A small percentage of broilers in the broiler trial developed leg problems, mainly in the cassava-based treatment group. A possible cause of this may have been low calcium and phosphorus. There was no time to analyse to diets to confirm the cause, and since the overall results were good, it

was decided to proceed with the on farm testing of rations unchanged. Possible sources of the problem may be the oyster shell or bone meals used. It may be more appropriate to formulate rations to contain 1.2 per cent calcium to take account of the lower than expected bioavailability of this mineral in oyster shells. A sample of bone meal was analysed subsequently (1997 sample in Appendix 6)and found to adequate calcium and phosphorus contents. Inadequate mixing of rations may also cause loss of minerals when dusty feeds such as tubers and roots are involved. For this reason it is necessary to provide small-scale poultry producers with a package of poultry technology including how to mix small quantities of feeds (see Appendix 16.8).

### 11.5.7.10. *Results of the on-station testing of first tentative layer rations (layer 2)*

211. The results of the layer trial are summarised in Table 21. The CAS-based ration produced a similar rate of egg production in terms of hen-day production and mass of eggs laid but the production rate with SP-based ration was 21 per cent lower. Food intakes were highest on the commercial ration, followed by the CAS-based ration, and lowest on the SP-based ration. In laying hens the efficiency of lay is not easily measured over short periods of feeding, particularly with diets associated with anti-nutritional factors (such as trypsin inhibitors in SP) including unsuitable feed texture such as the powdery nature of tubers and roots. However, figures for number and mass of eggs per kg feed consumed were best for the CAS-based ration followed by commercial ration and then the SP-based ration. The lower food intakes in the SP-based ration compared with the CAS-based rations may indicate that the texture of this feed is worse than that of SP, and resulted in the lower productivity of hens. The coarsely ground nature of WPK could also have had a deleterious effect on food intake.

212. However, for the same consideration as those applied for broilers (paragraph 186) it is necessary to examine the 'bottom line' when determining whether the rations might be suitable for on farm transfer. Due to the higher food intake associated with the commercial diet, the cost of feed used to produce a tray of 30 eggs were 951, 650 and 1306 FCFA for the SP-based ration, CAS-based ration and the commercial ration, respectively; the corresponding profit margins being 399, 700 and 44 FCFA. Using this criteria, it was still considerably more profitable for small-scale producers to use the SP- and CAS-based rations.

213. The eggs produced by the various treaments were also checked for egg quality by assessing yolk colour (using the Roche colour fan), Haugh Units, Shell weight and thickness, and meat and blood spots. The only significant finding was the paler yolks of the yolks in the SP- and CAS-based diet groups. It is, however, not clear whether the yolk colours were too pale to be acceptable to consumers. There were no signs of gossypol-related brown yolk discolorations in freshly laid eggs arising from the inclusion of CSC in the rations. Egg storage studies were not conducted.

**Table 21. Summary of results from the on-station testing of broiler chick diets designed for the first on-farm broiler feeding trials. Feeding trial took place during December and January 1995-1996.**

| | Sweet potato-tuber-based diet | | Cassava root -based diet diet | | Commercial | | SEM | | Significance of dietary effect (P<or=) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weeks of feeding** | **0-4** | **0-8** | **0-4** | **0-8** | **0-4** | **0-8** | **0-4** | **0-8** | **0-4** | **0-8** |
| Liveweight (kg) | 0.394[a] | 0.882[a] | 0.562[b] | 1.439[b] | 0.734[c] | 1.819[a] | 7.09 | 27.68 | 0.0001 | 0.0001 |
| Food intake (kg) | 0.952[a] | 3.077[a] | 1.163[b] | 4.116[b] | 1.408[c] | 4.657[a] | 20.01 | 62.72 | 0.0001 | 0.0001 |
| EFU (gain/feed) | 0.407[a] | 0.289[a] | 0.477[b] | 0.341[b] | 0.518[c] | 0.389[a] | 0.0065 | 0.0054 | 0.0001 | 0.0001 |
| Cost feed/kg gain (FCFA) | 337.0[a] | 477.7[a] | 257.2[b] | 360.1[b] | 464.7[c] | 619.0[a] | 4.96 | 7.95 | 0.0001 | 0.0001 |
| % Savings on Diet C | 27.33[a] | 22.83[a] | 44.65[b] | 41.83[b] | | | 1.26 | 1.46 | 0.0001 | 0.0001 |

Each figure is the mean of 8 replicates. SEM = Pooled standard error of means. Within each of the 0-4 and 0-8 week data, values in the same line with different superscripts are significantly different (P<0.05).

**Table 22. Summary of results from the on-station testing of layer rations designed for the first on-farm layer feeding trials. 20 month-old individually caged laying hens were fed for 8 weeks. Feeding trial took place during November and January 1995-1996.**

| Treatments | SP-based diet | CAS-based diet | Commercial diet | RMSE | *Significance* (P=<) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Tier | IWT | Diet |
| Total food intake (g) | 5008$^{a}$ | 5239$^{a}$ | 5730$^{b}$ | 506.3 | 0.4674 | 0.0004 | 0.0069 |
| Food intake (g per hen d) | 89.4$^{a}$ | 93.5$^{a}$ | 102.3$^{b}$ | 9.04 | 0.4674 | 0.0004 | 0.0069 |
| Total number of eggs laid | 21.75$^{a}$ | 29.49$^{b}$ | 27.55$^{b}$ | 6.218 | 0.6283 | 0.9029 | 0.0047 |
| Hen day production | 0.388$^{a}$ | 0.527$^{b}$ | 0.492$^{b}$ | 0.111 | 0.6283 | 0.9029 | 0.0047 |
| Change in body weight (g) | -118$^{a}$ | -84$^{ab}$ | -17$^{b}$ | 93.98 | 0.2105 | 0.0008 | 0.0509 |
| Total mass of eggs laid (g) | 1274$^{a}$ | 1672$^{b}$ | 1626$^{b}$ | 329.4 | 0.6578 | 0.6812 | 0.0048 |
| G eggs per hen d | 22.75$^{a}$ | 29.86$^{b}$ | 29.03$^{b}$ | 5.88 | 0.6578 | 0.6812 | 0.0048 |
| Mean egg weight (g) | 58.57 | 57.19 | 59.26 | 2.958 | 0.7104 | 0.0551 | 0.1801 |
| G eggs per kg feed | 256$^{a}$ | 319$^{b}$ | 286$^{ab}$ | 57.4 | 0.5426 | 0.1862 | 0.0136 |
| Number of eggs laid per kg feed | 4.38$^{a}$ | 5.65$^{b}$ | 4.86$^{ab}$ | 1.098 | 0.5236 | 0.0877 | 0.0080 |
| Feed cost per kg eggs (FCFA) | 525$^{a}$ | 370$^{b}$ | 751$^{c}$ | 50.2 | 0.5687 | 0.1621 | 0.0001 |
| Feed consumed per tray of eggs (kg) | 7.36$^{b}$ | 5.62$^{a}$ | 6.39$^{ab}$ | 1.766 | 0.5982 | 0.1196 | 0.0310 |
| Feed cost per tray of eggs (FCFA) | 951$^{a}$ | 650$^{b}$ | 1306$^{c}$ | 251.2 | 0.6237 | 0.1542 | 0.0001 |
| Profit margin per tray of eggs (FCFA) | 399$^{a}$ | 700$^{b}$ | 44$^{c}$ | 251.2 | 0.6237 | 0.1542 | 0.0001 |

**Notes**: Least square means adjust for Tier and initial body weight (IWT) as covariates; RMSE Root Mean Square Error. No of hens per treatmet 19 in Diets A and B, 15 in Diet C. Diet Cost (FCFA/kg): A 129.11, B 115.45, C 200. Farmgate price for a tray (30) of eggs - FCFA 1350. Values in the same line with different superscripts are significantly different ($P<0.05$).

### 11.5.7.11 *Implications of the findings of on-station testing of first tentative rations for the on-farm testing stage*

214. Although the production rate achieved on the SP-based rations was lower than desired, the broiler ration in particulary was sufficiently more profitable in relation the commercial ration. The CAS-based rations were even more profitable for both broilers and layers, although there was some concern that the yolk may be too pale in colour to be acceptable in the region. Of particular relevance to the target poultry producer these rations significantly reduced their cash outlay on feed considerably from current practice of total reliance on commercial feeds. A vast majority small-scale poultry producers in the region are also involved in crop production so that they would be able to generate their own SP or CAS. Most smallholders also own one or two palm trees, and the palm fruits are processed in village pits to extract oil leaving behind the PPS and WPK. Thus potentially, with 50 per cent SP- or CAS, 14 per cent WPK and 6 per cent PPS 70 per cent of the ration could be farm-produced feed.

215. It was decided to proceed with on-farm testing of the rations developed without any modifications of the rations. However, in addition to the profitability of the cereal-free rations, two aspects of farmer responses would in particular be monitored: the acceptability of production rates achieved; and the acceptability of resulting yolk colour.

### 11.5.8. *Testing the first project developed poultry rations in on-farm trials*

216. The main objective of the on-farm trials was to test the project-developed tuber and root-based poultry rations under farmer conditions to determine their applicability. Three diets were to be compared: (a) a SP-based ration; (b) a CAS-based ration, and (c) the 'best' commercial diet (Tables 18-19). The project-developed feeds and chickens were provided to be provided to farmers for testing under their own management conditions. The second objective was to demonstrate the use of of low-cereal or cereal-free poultry feeds to small-scale poultry producers and to promote the technology to other producers and potential producers in the western highlands of Cameroon. This was to be achieved by a combination of (a) selecting appropriate participants for the on-farm trials; (b) organising visits by people interested in poultry rearing to these premises, the on-farm trials thus serving as 'demonstration' trials); and (c) organising public meetings at the research station with project participants and other economic stakeholders. The selection of one male farmer who owned a small-scale animal feed shop, the village leader, and the PRTC were based on the consideration that these participants represented possible diffusion pathways for the promotion of project-generated technologies (paragraphs 117-119). Thus, the terms of farmer participation was an important consideraton in project design.

#### 11.5.8.1. *Terms of farmer participation*

217. Apart from the considerations discussed earlier (paragraphs 109-119) other criteria were important for selection in relation to the 'ration testing' objective. All farmers should have had at least 1 year of experience in poultry rearing of the broiler or layer type so that they did not make mistakes in animal husbandry (refesher training would be provided in this). Participants must also have poultry houses that are suitable for partitioning into three segments so that birds could be fed the three dietary treatments in separate compartments but within the same building to ensure that they were subject to similar conditions for comparison. All potential participants were interviewed and only those selected who agreed to maintain records of poultry performance. This would be daily food intakes in the case of broilers, and for egg production, daily record of food intakes and eggs laid, with eggs being graded according to small, middle and large eggs . Training and appropriate data sheets would be provided in each aspect prior to the feeding trials. Researchers will however weigh the birds at the start middle and end of the feed trial periods due to the greater accuracy equipment required.

218. To assist the 'demonstration' objective particpants were also required to allow visits to their premises during the on-farm trials by resource-poor poultry producers or those expressing a wish to start poultry rearing activities. To minimise inconvenience to participants these would be group visits regulated by MRS rather than haphazard individual visits.

219. To induce participation and because of the uncertainty on whether the rations developed would be successful, the participants would be given chickens and feeds free of charge and would be allowed to keep the proceeds from sales of chickens and eggs. However, farmers dropping out of the trials would be required to return the laying hens to MRS. Each participant was to be given up to 75 newly laying hens (reared at MRS from day-old) and up to 75 day-old broiler chicks for allocation to the three dietary treatments at 25 chicks per treatment although in the event fewer birds were given (see below). Logistical problems prevented the use of more than one replicate per farm. Sufficient test diets would be given to enable feeding for a period of 15 weeks for layers and 8 weeks for broilers.

### 11.5.8.2. *Particulars of particpants and their poultry facilities*

220. *Male Farmer A*. Mr. John Ngwa was a driver living in Muwachu: 2 km West of IRZV, Akemnebang village in Mankon. and also rears rabbits and chickens of both the broiler and layer strain and grows crops. He kept 39 chickens in the main building in another partition he keeps 3 hens and a cock and a similar number in a third room. His fertile eggs are bought by a local person who incubates them. His reported that 7 out of 10 eggs hatch out, but 3 develop and are unable to hatch. The poultry house was on stilts and the floor made of the raffia bamboo with slits that to allow rain water to escape. However, other associated advantages of this system is that litter (such as wood shavings) are not required and excreta can fall through for easy collection and use as manure or kept for sale (Some farmers maintain a mixed floor system with part deep litter and part slatted floor, the latter being raised somewhat so that birds invariably perch on it for excretion).

221. Mr Ngwa followed a ration for laying hens and breeders that comprised of (%): maize 62.5 CSC 15.0, fishmeal 7.5, rice bran 4.5, bone meal 1.0, oyster shells 9.0, salt 0.5. The estimated nutrient content of this ration is as follows: CP 18.25; AME 11.42; calcium 3.81; phosphorus 0.82; salt 0.70; lysine 0.84; and methionine+cystine 0.98. The cost is 167 FCFA/kg compared with 200 FCFA/kg for commercial feeds. Mr Ngwa buys whole dry fish and grinds it himself in an electric mill owned by a relative for grinding maize brought to the mill by local farmers. He enquired whether he could use PKC from the traditional method (paragaph 121) for feeding chickens, but was especially concerned about maize. The high cost of maize has led him to keep a look out for infested maize in the market which is available in large quantities towards the end of the dry season. For this Mr Ngwa goes to rural households and purchases them at a third of the market price of good quality maize. Some farmers in the low lying swampy areas (where water accumulates) of this high rainfall highlands may obtain up to 3 crops a year of maize. The first crop is harvested in August so that there are still many rainy months ahead. This crop needs to be artificially-dried indoors using log fire ovens to ensure that the moisture content is kept 12 per cent. However, small-scael farmers are not able to afford artificial oven drying systems which are also environmentally unsustainable in view of the diminishng fuelwood resources in the region. Consequently, it is common for them to rely on a combination of sun-drying in between rain showers and indoor drying. This means that the first crop in particular is not well dried. Insect infestation and fungus colonisation takes place on stored maize. When the time for marketing arrives farmer separates the good maize from the bad maize (has green elements of fungus and is insect infested) selling each separately.

222. Mr Ngwa enquired whether it was safe for him to use 'bad' corn. Not much research has been done in this aspect of poultry nutrition, but it is probable from the fungus evident in samples and the 'stackburned' colour that mycotoxins (aflatoxins, trichothecenes, etc) would be produced during storage and harm chickens in terms of reduced growth of broilers and depression of egg

production in layers. Mr Ngwo complained about the low viability of the eggs from his breeders, which may be associated with aflatoxin-contaminated maize, particularly when consumed with the gossypol arising from the high level of CSC he uses. It is possible that the harmful effects of fungus infested maize would not not persist if the ration is changed to the use of good quality maize periodically. His own experiments with maize gave Mr Ngwa the ideal profile for the demonstration of the project concept of replacing maize with SP and CAS, which, unlike maize, is available in large quantities as the beginning of the dry season and can be gritted and sun-dried (that is without the use of fossil fuel) and stored for feeding to chickens for up to six months, as indicated from the on-staiton Tuber and Root Storage Broiler Trial 2 (paragraph 159). Further, the resource management issues surrounding maize for small-scale resource poor farmers revealed in this case study exemplifies the importance of the present project in developing countries.

223. For the on-farm trials Mr Ngwa was given 60 day-old broiler chicks and 45 laying hens. His poultry houses consisted of the following.

***Broiler house***: This was a windowed-building had walls made of plastered sun-dried muc blocks on the walls and roofed with corrugated zinc sheets. The cemented floor was covered with wood shavings as litter. The room was partitioned with raffia bamboo/mats and eucalyptus poles. In each brooding pen there was one standing hover (40 cm above floor level) covered with empty used bags and 3 kerosene bush lamps (0-3 weeks of birds age). Two powdered milk tin (1 litre capacity) with two holes placed laterally at the edge and inverted on a plastic tray served as drinkers up to 2 weeks of birds age. From there on, a 5-litre plastic bucket also with two lateral holes and inverted on a larger plastic tray was used. For feeding, two plastic trays were used during the first week and one wooden trough per pen during the rest of the feeding trial.

***Layer house***: The building was an all-raffia bamboo wall structure with raised bamboo slatted floor (80 cm above floor level), roofed with corrugated zinc sheets. Eucalyptus poles were used for framing. Partitioning was done with poles and raffia bamboos. Laying nests were made of plywood material and divided into six boxes. One -litre plastic bucket with lateral holes and inverted on a plastic tray served as a drinker. A wooden feeding trough was provided per pen.

224. *Male Farmer B*. Mr Wilfred Fai was a retrenched civil servant and is involved in crop farming, poultry rearing and petit trading. The trading includes mixing and selling animal feeds to small-scale livestock producers. He is based in Ntarkah: 1 km east of MRS. There was a special reason for selecting this farmer. Small-scale agroprocessing is a vital component of agricultural systems as they provide a valuable service to the local community. Small-scale manufacture of compound animal feed is a highly neglected area of development. This farmer mixing feeds using bucket and floor mixing techniques provide small quantities of mixed feeds to local small-scale livestock owners, and can therefore serve as a vehicle for the adoption of the outputs of this project. Large-scale feed millers using sophisticated milling technology are unable organise the feed developmental work necessary to adopt the technology of the project, but small-scale millers with good local contacts with farmers and who are stakeholders in the the local community will, it is believed, be able to. There were at least 50 small-scale livestock producers of chickens, pigs, rabbits and cattle who purchased feeds from Mr Fai and relied on him for advice on animal feeding. It was therefore considered that this person would be an appropriate candidate for on-farm testing as this could lead to a market forces driven diffusion of the project developed technologies. For this reason, in addition to seeking his participation in the on-farm demonstration trials further advice was given to this Test farmer at the end of the on-farm trials (Appendix 16.8). For the feeding trials Mr Fai received 72 day-old broiler chicks and 45 laying pullets.

***Broiler & layer house***: The building was an all-raffia bamboo (see Appendix 14 Plate 2) wall structure roofed with corrugated zinc sheets and with a bared floor covered with a 10 cm thick wood shavings litter material. Partitioning was done with eucalyptus poles and raffia bamboos. There were 3 pens for broilers and the same for layers, within the same room. Polyethylene sheets were used as insulator and placed round the whole building. In each broiler pen, there was one standing cardboard paper framed for partial (one-third of room space) brooding (0-3 weeks of bird age) and equipped with one kerosene bush lamp. Two powdered milk tin (1 litre capacity) with two holes placed laterally at the edge and inverted on a plastic tray served as drinkers up to 2 weeks of birds age. From there on, a 5-litre plastic bucket, also with two lateral holes, and inverted on a larger plastic tray was used. In each layer pen, one 5-litre bowl containing a weight (stone) was provided for daily fresh water supply. For feeding, two plastic trays were used during the first week and one wooden trough per broiler pen during the rest of the feeding trial. In each layer pen, a wooden trough feeder was placed. Per pen, a laying nest unit made of raffia bamboo material and divided into four boxes was provided.

225. *Female Farmer A*. Mrs Esther Geh was a retired nurse and involved in crop farming and poultry rearing. She lived in Nitop, about 5 km east of MRS (Akemnebang). She was given 60 day-old broiler chicks.

***Broiler house***: This was a windowed-building had walls made of plastered cement blocks for the walls and the roof with corrugated zinc sheets. The cemented floor was covered with wood shavings as litter. The room was partitioned into three pens using raffia bamboos, card board papers and eucalyptus poles. Brooding was done using a hanging hover with one 100 watt electrical bulb per pen. Two powdered milk tin (1 litre capacity) with two holes placed laterally at the edge and inverted on a plastic tray served as drinkers up to 2 weeks of birds age. From there on, a 5-litre plastic bowl put on the floor but protected with a standing fish-like nest trap made of tree branches to keep chickens away from getting into it served as a drinker (Appendix 14 Plate 6). For feeding, two plastic trays were used during the first two weeks and one wooden trough per thereafter.

226. *Female Farmer B*. Mrs Fride Makambou was a housewife and engaged in crop farming, poultry rearing and petit trading. She lived in Old Town, 10 km East of MRS (Akemnebang). She was given 60 laying pullets.

***Layer house***: This was a windowed, all-concrete building was made of plastered cement blocks on the walls and roofed with corrugated zinc sheets. The cemented floor was covered with wood shavings as litter. The room was partitioned into three pens each having a separate window. Laying nests were made of plywood material and divided into four boxes. One 5-litre plastic bucket with lateral holes and inverted on a plastic tray served as a drinker. A wooden feeding trough was provided per pen. Two powdered milk tin (1 litre capacity) with two holes placed laterally at the edge and inverted on a plastic tray served as drinkers up to 2 weeks of birds age. From there on, a 5-litre plastic bucket, also with two lateral holes, and inverted on a larger plastic tray was used. In each layer pen, one 5-litre bowl containing a weight (stone) was provided for daily fresh water supply. For feeding, two plastic trays were used during the first week and one wooden trough per broiler pen during the rest of the feeding trial. In each layer pen, a wooden trough feeder was placed, and a laying nest unit made of raffia bamboo material divided into four boxes was provided.

227. *PRTC*. The Centre is located 30 km north of IRZV Mankon in Mfonta, a village in Bambui, Tubah district. Their major activities are religious worship and the training of rural farmers, demonstrating agriculture technolgies and undertaking rural developmental projects. Their work was conducted with youth, women and men. They train people to go to the villages and give advice on farming. Prior to 1993, PRTC used to prepare poultry feeds for their own use in the training centre for the purposes of training people in poultry husbandry, and selling this feed to people whom came to buy it. However, their poultry project folded due to high cost of feeds and chickens. The previous rations used are shown in Table 22. Taking the laying hen ration as an example the cost was approximately the same as for commercial layer's mash. the nutrient contents of all diets were imbalanced as seen for example in the phosphorus contents.

**Table 23. Poultry rations used by the Presbytarian Rural Training Centre prior to the project.**

| | Layer Starter chick | Layer Grower chick | Laying hen |
|---|---|---|---|
| Maize | 51 | 41 | 50 |
| Soyabean meal | 27 | 16 | 30 |
| Rice bran | 17 | 37.5 | 10.5 |
| Bone meal | 4.5 | 5 | 9 |
| Salt | 0.5 | 0.5 | 0.5 |
| ***Cost (FCFA/kg)*** | 192 | 133 | 206 |
| ***Estimated nutrient analyses*** | | | |
| Crude protein | 18.1 | 15.1 | 18.6 |
| AME | 11.60 | 11.53 | 10.98 |
| Calcium | 1.71 | 1.87 | 3.33 |
| Phosphorus | 1.26 | 1.56 | 1.88 |
| Lysine | 1.03 | 0.83 | 1.08 |
| Methionine+cystine | 0.75 | 0.62 | 0.77 |
| Salt | 0.55 | 0.56 | 0.56 |

228. Although staff could not show the broiler rations used, it is most likely to have been similar to the layer chick starter diet in terms. Not surprisingly, these rations became uneconomic in relation to large-scale competitors who are able to afford much higher standards of housing, husbandry and veterinary care for the chickens than small-scale resource-poor poultry rearers with the consequence that the feeds cannot be as productive in the latter's production system. There also appeared to be a lack of knowledge concerning feed quality. For example, it was stated that CSC was used at one time but discontinued because one batch became 'mouldy'. This exemplified how much training these trainers of rural extension workers required in poultry feeding to ensure that resource-poor farmers received reliable advice The idea is to make simple feeds, but at what cost and no use of cheap local material. PRTC was therefore considered an ideal NGO to serve the purposes of 'a demonstration farm particularly since it has easy access to the farmers of the region. Indeed, it was fortunate for the project to find this group within easy access of the MRS. PRTC were given 60 one day-old broiler chicks and 60 laying pullets for the on-farm trials.

***Broiler house***: This was an open-sided building made of sun-dried mud blocks plastered half way from the bottom and chicken wire at the top. Polyethylene sheets were used to cover the chicken wire to preserve heat during brooding. The building was roofed with corrugated zinc sheets. The cemented floor was covered with rice hull litter. The room was partitioned with raffia bamboo and eucalyptus poles. Partial brooding was done on one-quarter of the pen using a box. On the first night, one kerosene bush lamp (KBL) was used and was found insufficient. This was increased to three per pen.

***Layer house***: This is shown in Appendix 14, Plate 2. The building had an all-raffia bamboo wall structure with raised bamboo slatted floor (40 cm above floor level) roofed with corrugated zinc sheets. Eucalyptus poles were used for framing. Partitioning was done with poles and raffia bamboos. One 10 litre plastic bucket (Appendix 14, Plate 5) served as drinker. This was secured on the slats with a wooden frame. Laying nests were made of plywood, divided into six boxes (Appendix 16.11 {Plates and ). A wooden feeding trough per pen was used.

229. *CAMWIDCO*. CAMWIDCO offices were based in Ntarikon, 1 km East of IRZV Mankon (in Bamenda). Their major activities were joint farming and marketing projects exclusively for women. They were involved in crop and livestock production in rural areas. The farmer was given 60 one day-old broiler chicks, and 60 laying pullets.

***Broiler & layer house***: The layer house was a windowed building with walls made of plastered sun-dried mud blocks, and a roof of corrugated zinc sheets. The cemented floor was covered with wood shavings as litter. The room was partitioned with Indian and Raffia bamboos and eucalptus poles. There were three pens for broilers and 3 pens for layers, within the same room. Brooding was done using one 100-watt electrical bulb per broiler pen. One chick fount (5 litres capacity) and two metal feeder troughs were provided for each broiler pen. In each layer pen birds had access to water through a 5-litre metallic drinker and fed from a metallic trough feeder. Laying nests were made of plywood (Appendix 16.11, Plates 7 and 8) and divided into six sections.

230. *Village leader*. Mr S.A. Angwafor was the traditional ruler of Mankon village and a political figure in village Ntor, 8 km south of IRZV, Mankon. He was involved in mixed farming activities (crop and livestock). Village leaders traditionally are regarded as owning the lands (even though government records may show them as national lands) and determined the farming systems in terms of what work was conducted in the villages and which land was to be left fallow or cultivated in the rotations. Mr Angwafor was respected in the village and it was for these reasons that he was selected for demonstration of the project concept, after much deliberation because of his priviledged and wealthy position in the area. He was given 60 one day-old broiler chicks and 60 laying pullets.

***Broiler house***: This was an open-sided building made of sun-dried mud blocks (Appendix 14, Plate 3) plastered three-quarters way from the bottom and chicken wire at the top portion. Polyethylene sheets were used as insulator for brooding purposes. The building was roofed with corrugated zinc sheets. The cemented floor was covered with a mixture of rice hulls and wood shavings as litter, with cost and water absorption characteristics being relevant in determining the mixture portions used (wood shavings rot easier than rice hulls that contains silica and is, therefore, more suitable for direct incoporation of poultry litter produced in the soil as manure). The room was partitioned with raffia bamboo, eucalyptus poles and plywood sheets. Brooding was done using a hanging hover with a 100-watt electrical bulb per broiler pen. One chick fount (3 litres capacity) and one metallic feeder trough was provided for each pen.

***Layer house***: The layer house is shown in Appendix 14, Plate 2. The building was a three-walled all-raffia bamboo and one walled un-plastered sun-dried mud blocks structure with raised bamboo slatted floor (60 cm above floor level) roofed with corrugated zinc sheets. Eucalyptus poles and raffia bamboos were used for framing and partitioning. Laying nests were made of plywood (Appendix 14, Plate 7). One 3-litre plastic chick fount served as drinker. One metallic feeding trough per pen was provided.

### 11.5.8.3. *Training given to participants*

231. To maximise the impact of the project, it was necessary to give explain the structure of the project and identify the roles of researchers and participants. Paricipants responsibilities included the supply of housing, feeders, management of birds and data collection while the project supplied chickens, drugs and feed, and analysed the data obtained. Training was given to participants in two specific aspects: (a) responsibilities in relation to poultry husbandry; and (b) poultry nutrition and feed production.

#### 11.5.8.3.1. *Training on general poultry husbandry*

232. For broiler chicks, the participants were told of the importance of brooding day-old chicks correctly. Farmers were advised to observe young chicks for their behaviour to see if brooding management was correct: if chicks they too cold, they would crowd around the heating source; if the were too hot, chicks would run away from the heat source; but if they are just comfortable, chicks would move all over the room feeding, drinking and playing. For the feeding and drinking

equipment, farmers were told of the need to have a sufficient number of these to enable *ad libitum* feeding conditions a vital assumption for the project. These equipment needed to be adapted to the chickens' age and size so that chickens should were free to eat and drink at will. The height of the equipment should be at the birds shoulder height level or slightly below. Each group of chickens would have its own broiler diet to be fed throughout the feeding trial. Participants were informed that although broiler chickens were routinely fed broiler starter and finisher rations in this on-farm trial, chickens would be fed the test rations from 0-8 weeks of age, but the commercial ration in its starter and finisher forms. Laying hens would be given layer diets at 18 weeks of age. As in the broiler trial, each group of chickens will be given a separate layer diet to be fed throughout.

233. The prevention of diseases and poultry house hygiene were important factors during the trials. House cleaning was essential, comprising of sweeping, scrubbing, cleaning, washing and disinfecting. A foot bath should be added at the entrance (inside) of the poultry house. The disease prophylactic programme consisted of a routine medication and vaccination programme for broilers and layers are shown in Tables 23 and 24, respectively.

**Table 24. Disease prophylactic programme for first on-farm broiler feeding trials**

| Bird age (days) | Disease problems | Medication and doses |
|---|---|---|
| 0-3 | Stress | Anti-stress: stress-stop, 5 g/3 litre water |
| 6-7 | Stress | Anti-stress: stress-stop, 5 g/3 litre water |
| 8 | NCD/Gumboro | Pestos and gumboral vaccination |
| 8-9 | Stress | Vitamin: 5 g/5 litre water |
| 11-14 | Bacteria | Antibiotics and cocciostat drugs |
| | Coccidiosis | 5 g/5 litre water |
| 15 | Deficiencies | Vitamin: 5 g/5 litre water |
| 19-20 | Stress | Antistress: stress-stop, 5 g/5 litre water |
| 21 | NCD | Booster dose (Lasota) vaccination |
| 21-22 | Stress | Vitamin: 5 g/5 litre water |
| 26-29 | Bacteria | Antibiotics drugs |
| 29-30 | Deficiencies | Vitamin: 5 g/10 litre water |
| 40-44 | Bacteria | Antibiotics and coccidiostat drugs |
| | Cocciodiosis | 5 g/litre water |
| 44-45 | Deficiencies | vitamin: 5 g/10 litre water |
| 49-52 | Stress | Antistress: stress-stop, 5 g/5 litre water |

**Table 25. Disease prophylactic programme for first on-farm layer feeding trials**

| Bird age (weeks) | Disease | Medication and doses |
|---|---|---|
| 24 | Stress | Anti-stress, 5 g/litre water for 3 days continuously |
| 26 | Deficiencies | Vitamins, 5 g/10 litre water for 3 days |
| 28 | Stress/worms | Stress-stop, 5/litre |
| 30 | Stress | Stress-stop, 5 g/5 litre water for 3 days |
| 32 | Deficiencies | Vitamins, 5 g/10litre water for 3 days |
| 34 | Stress | Stress-stop, 5 g/5 litre water for 3 days |
| 36 | Stress/worms | Stress-stop, 5 g/5 litre water for 3 days continuously; followed by 2 days with vitamin (5 g/10 litre water) |
| 38 | Stress | Stress-stop, 5 g/5 litre water for 3 days, continuously |
| 40 | Deficiencies | Vitamins, 5 g/10 litre water for 3 days continuously |
| etc. | | |

234. The floor density was an important factor. The following guidance was given:

**For broilers**: 25 birds should occupy a square metre from 0-2 weeks of age.
15 birds should occupy a square metre from 3 to 4 weeks of age.
8-10 birds should occupy a square metre above 4 weeks of age.

**For layers** 3-4 birds should occupy a square metre above 20 weeks of age

235. Finally, farmers were explained that accurate record keeping was a vital component of the project without which no analysis could be conducted of how successful the rations were in achieving the project objectives. For the laying hen trial, eggs were to be collected daily and sorted into three classes based on visual scores: small, medium and large. Samples of the egg grades were provided to farmers. Farmers were to sell graded eggs and keep records. Feed was measured into feeders using variable cups/cans (Appendix 16.11. Plates 9 & 10). Each farmer had his/her own cup. The same cup was used by farmer for layer and broiler mash. The actual weight of cup content per each farm was the average weight of ten measures taken by farmer.

236. For broiler chickens, daily feed intake (how may cups or cans of feed given), mortality count, and sales of chickens were to be recorded by farmers, but body weight at 4 and 8 weeks were to be conducted by researchers. Sample of broiler and layer data sheets for recording are shown in Tables 26 and 27. To minimise the risk of mistakes each room/diet had its own data sheet, and feeds were appropriately labelled, for example, 'Diet A fed to chickens in room A' (there is a high level of literacy in this nglophone area of Cameroon). For laying hens, chicken weighings were jointly carried out by the MRS team and farmer (Appendix 16.11, Plates 11, 12 and 14). daily feed intake (use a cup/can) and mortality count.

237. Participants would record the price at which project chickens were sold. This was to be done by hand 'feeling' of weights (Appendix 16.11, Plate 13) (meat-type chickens sold at 1500-1800 FCFA per chicken depending on size). For eggs visual grading of eggs into trays of 30 eggs each would be done (Appendix 16.11; Plate 13) (eggs were sold at 1200, 1350 and 1500 FCFA for small, medium and large eggs, respectively).

## Table 26. On-farm data sheet for broiler chickens.

Farmer's name: Room/Diet

| Date | Feed given (cups)* | Numbers dead | Observation/Medication |
|---|---|---|---|
| 15/3/96 | 2 | 0 | Stress stop 5 g / 3 litre water |
| 16/3/96 | 2 | 1 | Stress stop 5 g / 3 litre water |
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**Note**: See Appendix 19 for photographs of types of cups used. Each cup was calibrated for feed content weight, and the total number of cups of feed given then multiplied with the estimated per cup weight of each of three diets to obtain food intakes per diet.

**Table 27. On farm data sheet for laying hens.**

Farmer's name Room/Diet:

| Date | Feed given (cups) | Number dead | Eggs collected and grade | | | Observations/Medication |
|---|---|---|---|---|---|---|
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**Note**: See Appendix 16.11 for photographs of types of cups used. Each cup was calibrated for feed content weight, and the total number of cups of feed given then multiplied with the estimated per cup weight of each of three diets to obtain food intakes per diet.

**11.5.8.3.2.** ***Training poultry nutrition and feed production***

238. Whilst it was appreciated by project researchers that there was a limited amount of technical training that could be provided by the project or will be understood by the project participants, it was also considered appropriate that this was the only means of generating awareness of the quality of feed in terms of nutrients. Simple languages were worked out to do this (Box 1).

**Box 1. Adapting nutrition to a language suitable for training peasant poultry producers.**

*Nutrients were 'chemical substances' found in food when taken in the correct amounts enable plants and animals to grow well or maintain their health and weight. 'Bad' feedstuffs or poorly mixed feedstuffs in terms of 'proportions' used or 'old' and 'mouldy' ingredients give poor quality feed. If 'good' feed is adulterated to make it last longer, say with rice bran, it makes nutrients available in wrong amounts to the chickens which than does not grow as well or lay as many eggs. The nutrients of a feed can are obtained in a laboratory. Using the chemical composition, quantities of each feed item are determined to include in a ration for each kind of animal. One can use a hand calculator to determine these amounts but it is easy in a computer.*

*Chickens need energy for which fat, for example palm oil, is the richest source. The residues from the extraction of oil from seeds such as groundnuts, soyabeans, palm kernels and palm pit sediment (called oilcakes) also supply fat as well as reduce dustiness. However, the main energy source for poultry feed is maize but since there is a high demand for corn by people for food, other energy sources include cassava, sweet potato, the oilcakes, rice bran, etc. need to be used. Excess energy in the ration will give rise to very fatty chicken. Thus, consumer's taste must be considered.*

*Chickens also need protein for muscle building, for which fishmeal is the richest source. However, fishmeal is expensive because there is a high demand for it and at times it is scarce. Other protein sources include the oilcakes, brewer's dried grains, blood and meat meals and leaf meals. Protein in costly and too much protein in the ration is a waste of money because the body cannot store it and must convert it into fat or excrete it. So, inclusion rates must be fairly exact. Some oilcakes such as cottonseed cake contain poisons, which means there is only a certin amount of it that can be added into the ration.*

*Chickens also need vitamins but in tiny amounts. They are found in leaf meals and fish meals. These too have been extracted and are sold in various vitamin mixes on the market. Minerals are essential for good functioning of the body and for bone formation. Some are needed in very small amounts (for example, iron) while others are needed in larger quantities, for example calcium and phosphorus. The major sources of minerals are bone meal, oyster sea shells, egg shells and calabar chalk (limestone).*

*Feeds must be kept dry because a high-moisture content will give rise to mouldy feed. However, too low a moisture content will make the feed too dusty for easy handling so a balance is needed.*

**11.5.8.4.** ***Feed and bird rearing preparations for the first on-farm feeding trials***

239. The rations for the first on-farm trials were unchanged from those used at the on-station testing stage (paragraph 200) (Tables 18 and 19). Rations were mixed at MRS. Day-old broiler chicks were purchased a day before delivery to the farms. Laying hens were reared from day-olds at MRS and were all in lay in February 1996 when the on-farm trials commenced.

**11.5.8.5.** ***Results of the first on-farm broiler feeding trials (broiler 4)***

240. The results of the broiler feeding trials from individual farms are shown in Table 28 and those from all six farms are summarised in Table 29. After 4 weeks of feeding, the liveweights of chicks fed on the SP- and CAS-based diets were 27 and 30 per cent lower than those of chicks fed the commercial ration, the figures being 23 and 14 per cent, respectively, by 8 weeks of feeding; the differences were statistically significant. Food intakes of chicks fed on the SP- and CAS-based diets

were also lower but there was variability in the data among farms. The EFU during 0-8 weeks of the SP- and CAS-based dietary groups were 18 and 4 per cent lower than for the commercial diet group. The combined results from on-station and on-farm testing of broiler diets give the same trends (Table 30).

241. The lower productivity of chicks fed on the test rations was consistent with the results obtained in the on-station trials except that the rate of broiler growth with SP-based ration was considerably better. As at the on-station testing stage the SP- and CAS-based rations were more profitable than the commercial ration, when figures were converted to cost of feed used per kg liveweight gain, which were 382, 292, and 533 FCFA, respectively. Over the 8 week period, there were savings of 25 per cent and 46 per cent savings on feed costs by the SP- and CAS-based rations in relation to the maize-based commercial starter and finisher rations. The on-farm broiler trials confirmed the on-station data on each of the 6 demonstration farms. When the results of trials on farmers premises are pooled with the results found on-station (Appendix 16.11, Table 2) the same trend in production and profitability of production is observed. It would therefore appear reasonable to conclude that the project has achieved a sustainable, cereal-free, intermediate-intensity poultry production system based on SP- or CAS- that is appropriate both to the needs of resource-poor farmers and achieves efficient resource management from the point of view of the country.

**Table 28. Results on-farm broiler feeding trials in the six farms.**

| Rations | Sweet potato-based | | Cassava-based | | Commercial | |
|---|---|---|---|---|---|---|
| **Weeks of feeding** | **0-4** | **0-8** | **0-4** | **0-8** | **0-4** | **0-8** |
| **Male Farmer A:** | | | | | | |
| Liveweight (kg) | 0.807 | 2.086 | 0.625 | 1.971 | 1.010 | 2.546 |
| Food intake (kg) | 1.819 | 5.601 | 1.334 | 5.008 | 1.695 | 5.918 |
| Efficiency (gain/food) | 0.443 | 0.373 | 0.469 | 0.394 | 0.585 | 0.430 |
| Cost feed/kg gain | 309.64 | 368.21 | 259.88 | 309.43 | 410.74 | 557.97 |
| % Savings on Diet C | 24.62 | 34.01 | 36.73 | 44.54 | | |
| **Male Farmer B:** | | | | | | |
| Liveweight (kg) | 0.531 | 1.604 | 0.515 | 1.775 | 0.636 | 1.743 |
| Food intake (kg) | 0.919* | 3.302 | 1.124* | 3.954 | 0.608 | 3.679 |
| Efficiency (gain/food) | 0.578 | 0.486 | 0.406 | 0.449 | 1.046 | 0.474 |
| Cost feed/kg gain | 237.39 | 282.23 | 300.39 | 271.35 | 229.58 | 506.94 |
| % Savings on Diet C | -3.40 | 44.33 | -30.84 | 46.47 | | |
| **Female Farmer A:** | | | | | | |
| Liveweight (kg) | 0.757 | 1.621 | 0.571 | 1.711 | 0.843 | 2.005 |
| Food intake (kg) | 1.565 | 4.546 | 1.388 | 4.610 | 1.278 | 4.585 |
| Efficiency (gain/food) | 0.484 | 0.357 | 0.377 | 0.372 | 0.689 | 0.437 |
| Cost feed/kg gain | 283.46 | 384.40 | 323.05 | 328.16 | 348.55 | 549.12 |
| % Savings on Diet C | 18.68 | 29.997 | 7.32 | 40.24 | | |
| **CAMWIDCO - Womens group:** | | | | | | |
| Liveweight (kg) | 0.442 | 1.163 | 0.627 | 1.422 | 0.884 | 1.810 |
| Food intake (kg) | 1.388 | 3.300 | 1.148 | 2.675 | 1.709 | 3.894 |
| Efficiency (gain/food) | 0.319 | 0.353 | 0.547 | 0.532 | 0.492 | 0.465 |
| Cost feed/kg gain | 430.23 | 388.94 | 222.89 | 29.13 | 488.63 | 516.59 |
| % Savings on Diet C | 11.95 | 24.71 | 54.39 | 55.65 | | |
| **Village Leader :** | | | | | | |
| Liveweight (kg) | 0.699 | 1.771 | 0.602 | 1.747 | 0.854 | 2.140 |
| Food intake (kg) | 1.739 | 5.955 | 1.291 | 5.254 | 1.411 | 5.149 |
| Efficiency (gain/food) | 0.441 | 0.297 | 0.459 | 0.333 | 0.518 | 0.416 |
| Cost feed/kg gain | 311.09 | 460.94 | 265.25 | 366.26 | 463.62 | 577.83 |
| % Savings on Diet C | 32.90 | 20.23 | 42.79 | 36.61 | | |
| **PRTC - NGO:** | | | | | | |
| Liveweight (kg) | 0.424 | 1.344 | 0.580 | 1.983 | 0.814 | 2.193 |
| Food intake (kg) | 0.689 | 3.988 | 0.869 | 3.943 | 1.454 | 4.475 |
| Efficiency (gain/food) | 0.543 | 0.337 | 0.570 | 0.503 | 0.507 | 0.490 |
| Cost feed/kg gain | 252.58 | 406.87 | 213.69 | 242.15 | 473.71 | 489.85 |
| % Savings on Diet C | 46.68 | 16.94 | 54.89 | 50.57 | | |

Notes: Commercial ration: EPA Broiler Starter (0-4 weeks) and Finisher (4-8 weeks). * Figures are unreliable - assumed that 1 cup = 0.33 kg in calculations.

**Table 29. Summary of results of broiler chick feeding trials from all farms in the first (1995-96) on-farm trials. The trial took place in February-June 1996.**

| | Sweet potato tuber-based ration | | Cassava root based ration | | Commercial ration | | SEM | | Significance of Dietary effect (P<or=) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weeks of feeding** | **0-4** | **0-8** | **0-4** | **0-8** | **0-4** | **0-8** | **0-4** | **0-8** | **0-4** | **0-8** |
| Liveweight (kg) | 0.61[a] | 1.60[a] | 0.59[a] | 1.77[ab] | 0.84[b] | 2.07[b] | 0.028 | 0.065 | 0.0042 | 0.0290 |
| Food intake (kg) | 1.35[a] | 4.45[a] | 1.19[a] | 4.24[a] | 1.36[a] | 4.62[a] | 0.087 | 0.229 | 0.6801 | 0.8019 |
| EFU (gain/feed) | 0.47[a] | 0.37[a] | 0.47[a] | 0.43[a] | 0.64[a] | 0.45[a] | 0.033 | 0.014 | 0.0842 | 0.0691 |
| Cost feed/kg gain (FCFA) | 304.9[a] | 381.9[a] | 264.2[a] | 291.1[b] | 402.5[b] | 533.0[c] | 17.39 | 11.66 | 0.0154 | 0.0001 |
| % Savings on Diet C | 21.9[a] | 25.0[a] | 24.7[a] | 45.7[b] | | | 7.69 | 3.18 | 0.7252 | 0.0088 |

**Notes**: Each figure is the mean of 6 farms (one replicate per farm). SEM = Pooled standard error of means. Within each of the 0-4 and 0-8 week data, values in the same line with different superscripts are significantly different (P<0.05).

**Table 30. Summary of results testing the first tentative rations developed for target beneficiaries in all locations (on-station and on farm testing) (1995-1996).**

| | Sweet potato tuber-based ration | | Cassava root-based ration | | Commercial ration | | SEM | | Significance of Dietary effect (P=<) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weeks of feeding** | **0-4** | **0-8** | **0-4** | **0-8** | **0-4** | **0-8** | **0-4** | **0-8** | **0-4** | **0-8** |
| Liveweight (kg) | 0.58[a] | 1.50[a] | 0.58[a] | 1.72[ab] | 0.82[b] | 2.04[ab] | 0.027 | 0.068 | 0.0017 | 0.015 |
| Food intake (kg) | 1.30[a] | 4.25[a] | 1.19[a] | 4.22[a] | 1.37[a] | 4.62[a] | 0.076 | 0.205 | 0.6354 | 0.6804 |
| EFU (gain/feed) | 0.46[a] | 0.36[a] | 0.47[a] | 0.42[ab] | 0.62[b] | 0.44[b] | 0.029 | 0.014 | 0.0592 | 0.0479 |
| Cost feed/kg gain | 308.9[a] | 395.6[a] | 263.2[a] | 300.9[b] | 411.4[b] | 545.3[c] | 15.08 | 12.06 | 0.0026 | 0.0001 |
| % Savings on Diet C | 22.7[a] | 27.6[a] | 30.0[a] | 45.1[b] | - | - | 6.62 | 2.71 | 0.5970 | 0.0027 |

**Notes**: All on-farm feeding trials were conducted with one replicate per dietary treatment, whereas the on-station tests were conducted with 8 replicates per dietary treatment. SEM = Pooled standard error of means. Within each of the 0-4 and 0-8 week data, values in the same line with different superscripts are significantly different ($P<0.05$).

11.5.8.6. ***Results of the first on-farm egg production trials (layer 4)***

242. The results of on-farm layer trials are summarised in Table 31. The production rates achieved with both the SP- and CAS-based test rations were 50 and 57 percent than that obtained with the commercial diet. This was due to the lower food intakes associated with the tuber and root meals. The profitability of production on the SP-based diet was also poor when expressed in terms of the mass of eggs laid per 1000 FCFA spent on feed; however, profitabililty in terms of the number of eggs laid per 1000 FCFA spent on feed was more attractive on the SP- and CAS-based rations than on the commercial ration, due to the larger egg sizes in the latter. Overall, the results of the layer trial were not encouraging and differed from the findings from the promising results obtained in the on-station ration testing stage. It was also found that replacing maize with tubers and roots resulted in paler than acceptable yolks, and the diets need to be supplemented with a pigment source to make them marketable.

**Table 31. Summary of the results of on farm layer feeding trial from all six farms (0-9 week data).**

| Diet | Sweet potato tuber-based ration | Cassava root based ration | Commercial ration | SEM | Significance P= or < |
|---|---|---|---|---|---|
| Hen day production | 0.40$^a$ | 0.45$^a$ | 0.78$^b$ | 0.025 | 0.0001 |
| Food intake (g/ hen d) | 93.2 | 93.6 | 144.1 | 10.8 | 0.1202 |
| G eggs/hen d | 22.9$^a$ | 26.1$^a$ | 45.7$^b$ | 1.5 | 0.0001 |
| G eggs/kg food intake | 284.2 | 301.8 | 358.6 | 22.9 | 0.4039 |
| Number of eggs/kg food intake | 4.96 | 5.24 | 6.16 | 0.396 | 0.4511 |
| Number of eggs/1000 FCFA on feed | 38.4 | 45.3 | 30.8 | 2.61 | 0.1083 |
| G eggs/1000 FCFA on feed | 178.1 | 225.7 | 228.4 | 9.73 | 0.0911 |
| Mean egg weight (g) | 57.5 | 57.6 | 58.3 | 0.49 | 0.7781 |
| Change in body weight (g/hen/d) | 0.6$^a$ | 0.3$^a$ | 4.9$^a$ | 0.3 | 0.0001 |

243. The on-farm trials were conducted with newly laying hens (6 month old) in deep litter or raised slatted bamboo floor systems whereas the on-station testing stage of the same rations were conducted with 20 month-old caged laying hens. A number of explanations are being considered: (1) the age of the laying hen (that is the stage of production) may influence the acceptability of rations incorporating nutritionally-problematic feeds such as SP; that is, it is possible that laying hens, especially those at an age that is capable at producing at a high rate (of around 90 per cent production), should not be fed for attaining high profitability; whereas such diets might be highly appropriate later in the egg production cycle when hen-day production has fallen to around 50 per cent. (2) hens housed in caged and deep litter systems give different production responses because they consume more feed in the former and have a higher maintenance requirement in the latter owing to higher physical activity; or (3) differences in laying hen behaviour associated with the two housing systems may account for the different production responses. If either explanation (2) or (3) are correct, it may mean that only caged systems are suitable when unconventional feeds are used. However, a combination of factors may be involved so that the interpretation of data obtained thus far is obscure.

244. Another possibility to be considered is that if hens were used to feeding on the tuber and root-based rations early in life when gut morphology can change in response to feed characteristics, hens would then be adapted to such rations so that food intakes would be high when fed similar rations in the laying period. In the on-station testing of on-farm rations, 20 month old hens that had been fed for 16 weeks early in lay on SP and CAS based rations were used. It is therefore necessary

to conduct a feeding trial with laying hens in which SP and CAS-based rations are fed to chicks from day-old to the laying period using layer chick starter, layer chick grower and laying hen rations in order to determine whether hens can be adapted in this manner.

### 11.5.8.7. *Discussions with participants and public after the first on-farm trials*

245. The project research results were presented to the public that consisted of participating farmers, IRA/CIP managers, IRZV researchers, and economic operators in the town. Twenty five persons attended the session held on 11 October 1996. The following reactions to project results were recorded.

246. For broiler meat production, the general reaction was good. However , all participants agreed that the chickens fed the SP-based ration should be made to reach about 1.8 kg liveweight at 8 weeks as for the cassava white-based diet, even if it meant a slightly higher feed cost. As for the laying hens, farmers were also concerned that layers produced much less eggs than would be acceptable. Researchers explained to the farmers that they were not clear on why production and productivity rates were so low. However it was further explained that this was a research project designed to identify solutions that would be appropriate to the needs of the resource-poor farmer and the project will continue to seek these solutions in particapation with the main target beneficiaries in the region.

247. Given that broiler keeping is considerably more important to resource-poor farmers than layer keeping (the reason being a complex issue related to a mixture of investment costs and an inability to compete in the market place with commercial feeds in basic housing systems, and other factors), participants and the public were extremely keen to follow up the recommendations of the project due to the very high price of maize. The logistics of disseminating the relevant technologies were discussed. The IRA and CIP managers suggested that if the demand for tubers and roots increased as a result of the project findings, they could make all the necessary tuber and root planting materials available to multiplication farmers at a cost of 2 FCFA for each 30 cm cutting. The President of the women group participating in the project (CAMWIDCO) said that tubers could be produced in the quantities required by her group all year round. This comment was supported by other meeting attendants.

248. Participants voiced their wish to acquire a large corn-mill type manual and/or motorised gritting machine that can be jointly purchased by women and youth groups. The principal of the PRTC (project particpating NGO) said that he would look into the possibility of the basic design of the said machine following the first prototype chipper that was commissioned by the project (paragraphs 247-). Other economic operators attending the meeting said that the multiplication of the gritting machine developed would not be a problem once a suitable prototype was designed. This should then lead to large-scale production of SP and CAS grits.

### 11.5.8.8. *Implications of the results of first on-farm trials for target beneficiaries*

249. The feeding trials conducted thus far using rations incorporating ground SP and CAS have yielded mixed results. On the one hand, the broiler rations developed showed considerable promise for application on-farm although the results were not as good as researchers had expected. The layer trials were also not good, due to the feed texture or the coarsely ground nature of WPK. Thus, although the feeding trials demonstrated that maize-free rations can be developed using roots and tubers which farmers will adopt, there is still much scope for improving the rations to make these cheaper and better in terms of their production potential. The follow-up discussions with participating poultry producers showed that the sweet potato broiler ration in particular needs to be improved. In January 1997, additional funds were sought from the LPP to conduct another phase of adaptive research on ration development and the development of the gritting machine.

### 11.5.9. *Design of feeding trials for improving the first project-developed poultry rations*

250. At this stage the results of the NRI Phase 2 Part 2 trials with SSF SP and CAS and cassava leaf meal (CLM) were available (Section 11.4.3.3). The indications in those '*look-see*' trials were that SSF technology may improve food intakes of ground SP and CAS-based rations, while CLM might be used to supply protein and yolk pigmentation. Thus, it is possible that improvements to both the broiler and layer rations could be achieved by using finely-ground WPK instead of coarsely-ground material; using a higher inclusion rate of palm pit sediment and using it for broilers as well as layers; using 48-hour solid-state fermented roots and tubers instead of unfermented material; using tuber and root grits instead of the meals (the value of grits being demonstrated in the preliminary gritting trials conducted); and using cassava leaf meal to supply protein, but more importantly for layers, pigmentation for yolk colour. An additional problem encountered was the lower than expected calcium bio-availability of the local oyster shells due to the low-technology used in the production process; it is, therefore, necessary to raise the calcium content of rations above those used in the previous feeding trials. The problem of data interpretation in the on-farm layer trial (paragraphs 225-227) will be resolved by testing selected layer rations under different conditions.

251. To address both the above issues, a set of broiler and layer rations were designed for testing beginning in March 1997. The dietary treatments for the broiler trial are:

Treatment A -Unfermented SP
Treatment B -48 hrs solid state fermented SP before sun-drying.
Treatment C - Unfermented CAS
Treatment D - 48 hrs fermented CAS before sun-drying
Treatment E - 48 hrs fermented CAS before sun-drying + 5 % cassava leaf meal (CLM)
Treatment F - Optimal 48 hrs fermented CAS-based diet for project site region
Treatment G - Optimal 48 hrs fermented SP-based diet for project site region
Treatment H - Best Commercial starter (0-4 weeks) and finisher (4-8 weeks) diets.

252. The dietary treatments for the layer trial are:

Treatment A -Unfermented SP, with 3.5 % CLM
Treatment B -Unfermented CAS, with 6.5 % CLM +fine-ground whole palm kernels (WPK)
Treatment C - Best Commercial ration
Treatment D - Unfermented SP, with coarse-ground WPK
Treatment E - Unfermented SP, with fine-ground WPK
Treatment F - 48 hr fermented SP, with fine-ground WPK
Treatment G - Unfermented CAS, with coarse-ground WPK
Treatment H - Unfermented CAS with fine-ground WPK
Treatment I - 48 hr fermented CAS, with fine-ground WPK

253. The composition of the rations are shown in Tables 26 and 27. The treatment considerations relating to the two types of chickens had similiarities but also major differences. However, for each rations were designed to build on the knowledge already gained in the previous trials, that is regarding those results as the worst case scenario for both broilers and layers. Since there were no major differences in the response of broilers between the previous on-station and on-farm testing stages of rations, the broiler rations will be tested only in on-station conditions to reduce costs and improve the reliability of results. However, in view of the different results obtained in the two situations in the previous layer ration testing three of the treatments, namely Treatments A, B and C, will be tested using the same age of hens in on-station caged system, on-station deep-litter system, and on-farm deep-litter (two farmers) and slatted-floor systems.

254. The SSF was conducted in the same manner as was done for the samples prepared for the NRI Phase 2 Part 2 studies (Section 11.4.3.3), but using the AS4 plate of the TRS food processor.

The use of this plate was identified as being optimal in terms of ease of processing and drying, but not nutritionally (paragraphs 247- ). Care was taken to ensure that the drying process is completed to below 12 per cent moisture. Since a manual gritting machine of the appropriate specifications is still not available or guaranteed to be developed (see paragraphs 250- ), the sun-dried fermented SP and CAS were ground for inclusion in the feeds. The CLM was prepared in the same manner as was done for the NRI Phase 2 Part 2 studies (paragraph 108).

255. For broilers, Treatments F and G are the type of CAS- and SP-based rations that is believed to produce the maximum benefits to resource-poor farmers and achieve optimal resource management in the project site region if the rations show potential for implementation. First, rations for promotion should be nutritionally and economically the optimum diet for the target beneficiaries. It may be noted that Broiler Treatment F is priced at only FCFA 114 per kg (Table 26), which is significantly cheaper than the rations being tested in the first on-farm trials and, at the same time, the nutritional profile is considerably better at 22.43 % CP, 12.84 MJ AME/kg and 1.14 % lysine, when previously the respective ration achieved figures of only 22 %, 12.45 MJ AME/kg and 1.08 % lysine, respectively. The optimal nature of this ration arises from least cost feed formulation in which the SP or CAS content of the ration is not fixed and all feed ingredients are considered for inclusion up to their maximum permissible inclusion rates in pure nutritional terms. The Treatment also tests CLM, PPS and WPK at high levels and should, therefore, give yield information on the potential for using these feed materials in combination that take account of associative effects. Testing these rations alongside the other treatments should lead to the full set of research data to make final recommendations for promotion and extension.

256. At the time of the planning of the these trials, only limited funds were guaranteed (the post-FTR funds for the sub-component project F0060). This was only sufficient for raising 235 hens for the on-station layer caged part of the feeding trials and the on-station broiler trial. Whilst subsequent approval of the requested project extension was welcome, on-station deep litter and on-farm floor systems required another 500 point-of-lay hens which could not be obtained to start at the same age as the 235 hens already reared (a critical element in the design of layer feeding trials). Hens will, therefore, be specially reared to reach the same age as the 235 hens currently being used in the feeding trial, before the rations are tested in the different floor systems of production on-farm and on-station.

257. For these reasons, a separate work plan was agreed for the 500 additional hens. Lohman Brown chicks will be obtained as soon as possible and reared at MRS on deep litter on rations selected from those recommended to Male Farmer B (Appendix 16.8). The rations for testing are shown in Tables 34, 35 and 36. The SP and CAS needed for all additional work funded by the project extension will be purchased from local market. There will be four experimental SP- or CAS-based rearer rations (Treatments A, B, C and D) which will be compared with a commercial control ration (Treatment E), chicks being transferred from starter rations (Table 34) to the respective grower rations (Table 35) at 8 weeks of age. At 18 weeks hens will be transferred to laying hen rations in cages and sub-divided into 8 experimental SP-, or CAS-based groups (Treatments A1, A2 , B1, B2, C1, C2 and D1, D2) and a commercial control (Treatment E) consistent with their previous feeding regime (Table 36). For example, hens previously fed Ration A will be fed A1 or A2, etc. The effect of the reeding regime on the onset of lay (age at first lay, lay weight, layer feed consumed to first egg, and first egg weight), and subsequent impact on egg production will be recorded. Production responses will be recorded until 2 weeks before hens reach the age when they are ready for transfer to the on-farm stage of the main laying hen feeding trial.

258. When hens are transferred to on-farm deep litter (2 replicates) and slatted-floor (2) systems they will be fed for two weeks on commercial ration for acclimatisation before being transferred to Treatments A, B, and C in Table 33. Production responses will be monitored for 16 weeks.

259. The quantity of SP 1112 cultivated on MRS fields was also only sufficient to enable the on-station layer and broiler trials originally planned with the post-F0060 FTR funds. The rations for the additional hens will, therefore, be made using SP purchased from the local markets.

Table 32. **Treatments for the broiler feeding trial in deep litter system on-station. All WPK is fine-ground. Figures are in percentages unless otherwise indicated.**

| *Treatments* | A Unfer-mented SP | B 48-hr fermented SP | C Unfermented CAS | D 48-hr fermented CAS | E Unfermented CAS + CLM | F Optimal CAS (fermented) diet for region | G Optimal SP (fermented)- diet for region | H Best Commercial starter and finisher rations |
|---|---|---|---|---|---|---|---|---|
| *Ingredients*: | | | | | | | | |
| Salt | 0.024 | 0.024 | 0.232 | 0.232 | 0.116 | 0.124 | 0.098 | |
| Cassava leaf meal (CLM) | - | - | - | - | 6.000 | 6.000 | - | |
| Palm pit sediment (PPS) | 10.000 | 10.000 | - | - | 10.000 | 10.000 | 10.000 | |
| Whole palm kernels (WPK) | 13.318 | 13.318 | 14.296 | 14.296 | - | - | 8.948 | |
| Blood meal | 3.000 | 3.000 | 3.000 | 3.000 | 2.589 | 2.910 | 3.000 | |
| Bone meal | 0.544 | 0.544 | 1.076 | 1.076 | 1.537 | 2.015 | 0.799 | |
| Cottonseed meal | 8.739 | 8.739 | 20.295 | 20.295 | 20.294 | 20.294 | 16.252 | |
| Oyster shells | 0.989 | 0.989 | 0.844 | 0.844 | 0.482 | 0.076 | 1.178 | |
| Fishmeal | 13.386 | 13.386 | 10.257 | 10.257 | 8.982 | 8.706 | 9.724 | |
| Sweet potato tuber (SP) | 50.000 | 50.000 | - | - | - | - | 30.000 | |
| Cassava white (CAS) | - | - | 50.000 | 50.000 | 50.000 | 49.874 | 20.000 | |
| *Total* | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| *Ration cost (FCFA/kg)*[1] | 168.45 | 168.45 | 139.07 | 139.07 | 114.89 | 114.01 | 139.78 | 240 |
| *Calculated analyses*: | | | | | | | | |
| Crude protein | 20.500 | 20.500 | 22.75 | 22.75 | 22.34 | 22.43 | 21.02 | ? |
| Metabolisable energy (MJ/kg) | 12.17 | 12.17 | 13.20 | 13.20 | 12.85 | 12.83 | 12.50 | ? |
| Calcium | 1.200 | 1.200 | 1.200 | 1.200 | 1.200 | 1.200 | 1.200 | ? |
| Phosphorus | 0.700 | 0.700 | 0.800 | 0.800 | 0.800 | 0.850 | 0.700 | ? |
| Salt | 0.400 | 0.400 | 0.500 | 0.500 | 0.400 | 0.400 | 0.400 | ? |
| Lysine | 1.163 | 1.163 | 1.140 | 1.140 | 1.129 | 1.140 | 1.090 | ? |
| Methionine+cystine | 1.047 | 1.047 | 0.912 | 0.912 | 0.910 | 0.900 | 0.909 | ? |

**Note**: 1. Rations took into account the new price of WPK of 125 FCFA/kg in 1997 (rising from 20 FCFA in 1995-1996).

**Table 33. Treatments for layer trials using newly laying hens. Diets A, B and C will be tested in deep-litter on-station and on-farm and slatted-floor system on-farm; all diets will also be tested in on-station caged-hen system. Figures are in percentages unless otherwise indicated.**

| *Treatments* | A Unfer-mented SP fermented CAS | B fine-ground WPK, unfer-mented CAS | C Best Commercial ration | D coarse-ground WPK, unfer-mented SP | E fine-ground WPK, unfer-mented SP | F fine-ground WPK, 48-hr fermented SP | G commercial control-repeated | H fine-ground WPK, unfer-CAS | I fine-ground WPK, 48-hr mented CAS |
|---|---|---|---|---|---|---|---|---|---|
| *Ingredients*: | | | | | | | | | |
| Salt | 0.025 | 0.287 | - | - | - | - | - | 0.288 | 0.288 |
| Cassava leaf meal | 3.500 | 6.500 | - | - | - | - | - | 10.000 | 10.000 |
| Palm pit sediment (PPS) | 10.000 | - | - | 10.000 | 10.000 | 10.000 | - | 5.394 | 5.394 |
| Whole palm kernels (WPK) | - | 1.141 | - | 7.381 | 7.381 | 7.381 | - | - | - |
| Blood meal | 2.000 | 2.500 | - | 2.000 | 2.000 | 2.000 | - | 2.205 | 2.205 |
| Bone meal | 1.176 | 3.033 | - | 0.920 | 0.920 | 0.920 | - | 3.222 | 3.222 |
| Cottonseed meal | 5.037 | 13.000 | - | 3.626 | 3.626 | 3.626 | - | 13.000 | 13.000 |
| Oyster shells | 8.137 | 7.695 | - | 8.290 | 8.290 | 8.290 | - | 7.559 | 7.559 |
| Fishmeal | 12.840 | 7.026 | - | 14.000 | 14.000 | 14.000 | - | 6.143 | 6.143 |
| Sweet potato tuber (SP) | 40.000 | 8.818 | - | 53.783 | 53.783 | 53.783 | - | - | - |
| Cassava white (CAS) | 17.285 | 50.000 | - | - | - | - | - | 52.190 | 52.190 |
| ***Total*** | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| ***Ration cost (FCFA/kg)*** | 149.15 | 112.72 | 200 | 165.44 | 165.44 | 165.44 | 200 | 99.67 | 99.67 |
| ***Calculated analyses***: | | | | | | | | | |
| Crude protein | 17.00 | 17.25 | ? | 17.00 | 17.00 | 17.00 | ? | 17.28 | 17.28 |
| Metabolisable energy (MJ/kg) | 11.40 | 11.55 | ? | 11.25 | 11.25 | 11.25 | ? | 11.64 | 11.64 |
| Calcium | 3.800 | 4.000 | ? | 3.800 | 3.800 | 3.800 | ? | 4.000 | 4.000 |
| Phosphorus | 0.700 | 0.850 | ? | 0.700 | 0.700 | 0.700 | ? | 0.850 | 0.850 |
| Salt | 0.400 | 0.500 | ? | 0.401 | 0.401 | 0.401 | ? | 0.500 | 0.500 |
| Lysine | 1.016 | 0.913 | ? | 1.022 | 1.022 | 1.022 | ? | 0.900 | 0.900 |
| Methionine+cystine | 0.954 | 0.700 | ? | 0.994 | 0.994 | 0.994 | ? | 0.700 | 0.700 |

**Note**: For method of mixing PPS with roots and tubers see text. Rations changed to take account of the new price of WPK of 125 FCFA/kg in 1997 (rising from 20 FCFA in 1995-1996).

**Table 34. Experimental layer chick starter rations to be fed in deep-litter system on-station from 0-8 weeks.**

| | *Layer Chick Starter (0-8 weeks) A* | *Layer Chick Starter (0-8 weeks) B* | *Layer Chick Starter (0-8 weeks) C* | *Layer Chick Starter (0-8 weeks) D* | *Best Commercial Chick Starter (0-8 weeks) E* |
|---|---|---|---|---|---|
| *Ingredients (kg):* | | | | | |
| Salt | 0.251 | 0.257 | 0.191 | 0.176 | |
| Palm pit sediment | 5.000 | - | 5.000 | - | |
| Rice bran - no chaff | 15.000 | 15.000 | - | - | |
| | 4.347 | 3.186 | 12.293 | 2.691 | |
| | 2.000 | 2.000 | 0.095 | 2.000 | |
| | 0.786 | 0.621 | 1.442 | 1.216 | |
| | 7.000 | 7.000 | 7.000 | 7.000 | |
| | 1.696 | 1.721 | 0.870 | 0.972 | |
| | 4.311 | 5.365 | 7.108 | 7.272 | |
| | 15.000 | 15.000 | 15.016 | 10.193 | |
| | 15.000 | 15.000 | - | 18.000 | |
| | | | 40.000 | 40.000 | |
| | 29.609 | 34.850 | 7.985 | 6.480 | |
| | | | 3.000 | 4.000 | |
| | (in water) | (in water) | (in water) | (in water) | |
| | 100 | 100 | 100 | 100 | |
| *Cost per kg (FCFA)*[0] | 83.1 | 86.8 | 135.0 | 115.5 | >200 |
| | | | | | |
| *Analyses (% calculated):* | | | | | |
| Crude protein | 19.15 | 19.15 | 19.15 | 19.15 | |
| | 1.20 | 1.20 | 1.20 | 1.20 | |
| | 0.80 | 0.80 | 0.70 | 0.70 | |
| | 0.45 | 0.45 | 0.40 | 0.40 | |
| | 11.65 | 11.65 | 11.60 | 11.60 | |
| | 0.95 | 0.96 | 1.05 | 0.98 | |
| | 0.73 | 0.75 | 0.80 | 0.85 | |

*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.

**Table 35. Experimental layer chick grower rations to be fed in deep-litter system on-station from 8-18 weeks.**

| | *Layer Chick Grower (8-18 weeks) A* | *Layer Chick Grower (8-18 weeks) B* | *Layer Chick Grower (8-18 weeks) C* | *Layer Chick Grower (8-18 weeks) D* | *Best Commercial Chick Grower (8-18 weeks) E* |
|---|---|---|---|---|---|
| *Ingredients (kg)*: | | | | | |
| Salt | 0.298 | 0.257 | 0.207 | 0.223 | |
| Palm pit sediment | 4.261 | - | 5.000 | - | |
| Rice bran - no chaff | 19.379 | 19.944 | 17.338 | 16.836 | |
| Blood meal[2] | 0.786 | 0.448 | 2.000 | 2.000 | |
| Bone meal | 0.701 | - | 0.407 | 0.163 | |
| | 7.000 | 7.000 | 7.000 | 7.000 | |
| | 2.000 | 2.560 | 2.239 | 2.182 | |
| | 2.549 | 3.161 | 3.504 | 6.142 | |
| | 20.000 | 20.000 | - | 15.454 | |
| | 15.000 | 15.000 | 21.397 | - | |
| | | | 30.000 | 30.000 | |
| | 28.026 | 31.630 | 10.908 | 20.000 | |
| | (in water) | (in water) | (in water) | (in water) | |
| | 100 | 100 | 100 | 100 | |
| *Cost per kg (FCFA)* | 59.8 | 63.9 | 75.8 | 90.2 | 150 |
| | | | | | |
| *Analyses (% calculated)*: | | | | | |
| Crude protein | 16.41 | 16.40 | 16.40 | 16.40 | |
| | 1.20 | 1.20 | 1.20 | 1.20 | |
| | 0.80 | 0.73 | 0.70 | 0.70 | |
| | 0.45 | 0.40 | 0.40 | 0.40 | |
| | 11.45 | 11.40 | 11.40 | 11.40 | |
| | 0.73 | 0.73 | 0.76 | 0.88 | |
| | 0.60 | 0.61 | 0.70 | 0.64 | |

*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 PPS and sun-dried cassava to obtain the ratio in the ration as fed (e.g. 5 kg:30 kg for Chick Diet C). (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.

**Table 36. Experimental laying hen rations for feeding in cages from 18 weeks to the point when hens are transferred to on-station and on-farm deep-litter and on-farm slatted-floor systems to be fed rations A, B and C in Table 33 (these to be fed after 2 weeks acclimatisation on commercial ration in floor housing systems.**

| | *Laying hen (18 weeks-) ration A* | *Laying hen (18 weeks-) ration A1* | *Laying hen (18 weeks-) ration B* | *Laying hen (18 weeks-) ration B1* | *Laying hen (18 weeks-) ration C* | *Laying hen (18 weeks-) ration C1* | *Laying hen (18 weeks-) ration D* | *Laying hen (18 weeks-) ration D1* | *Best Commercial Laying hen ration E* |
|---|---|---|---|---|---|---|---|---|---|
| ***Ingredients (kg)*:** | | | | | | | | | |
| Salt | 0.187 | 0.156 | 0.200 | 0.171 | 0.083 | 0.077 | 0.088 | 0.094 | |
| Palm pit sediment | 5.000 | 5.000 | - | - | 5.000 | 5.000 | - | - | |
| Rice bran - no chaff | 0.709 | - | - | 1.975 | 5.224 | 5.941 | 10.785 | 9.721 | |
| Soyabean meal | 13.727 | 9.908 | 13.932 | 10.560 | 6.803 | 6.120 | 4.362 | 4.989 | |
| | 1.811 | 1.347 | 1.803 | 1.157 | 0.573 | 0.414 | 0.267 | 0.337 | |
| | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 | |
| | 9.108 | 9.150 | 9.323 | 9.593 | 9.852 | 9.935 | 10.000 | 10.000 | |
| | 4.448 | 7.572 | 5.277 | 7.980 | 10.814 | 11.354 | 12.000 | 11.407 | |
| | - | 14.789 | - | 11.564 | - | 2.159 | 2.498 | - | |
| Brewers dried grains | 15.000 | - | 13.151 | - | 2.651 | - | - | 3.452 | |
| Sweet potato tuber | - | - | - | - | 30.000 | 30.000 | 30.000 | 30.000 | |
| Cassava roots | 43.010 | 45.077 | 49.314 | 50.000 | 20.000 | 20.000 | 20.000 | 20.000 | |
| Palm oil | - | - | - | - | 2.000 | 2.000 | 3.000 | 3.000 | |
| | (in water) | (in water) | (in water) | (in water) | (in water) | (in water) | (in water) | (in water) | |
| | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | |
| | 109.1 | 111.4 | 115.9 | 118.3 | 133.4 | 133.9 | 137.7 | 136.7 | 200 |
| | | | | | | | | | |
| ***Analyses (% calculated)*:** | | | | | | | | | |
| Crude protein | 17.50 | 17.50 | 17.50 | 17.50 | 17.50 | 17.50 | 17.50 | 17.50 | ? |
| Calcium | 4.00 | 4.00 | 4.10 | 4.10 | 4.10 | 4.10 | 4.10 | 4.10 | ? |
| | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.76 | 0.74 | ? |
| Salt | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | ? |
| Metabolisable energy (MJ/kg) | 11.50 | 11.50 | 11.50 | 11.50 | 11.50 | 11.50 | 11.50 | 11.50 | ? |
| Lysine | 0.87 | 0.94 | 0.89 | 0.96 | 0.97 | 0.98 | 0.99 | 0.97 | ? |
| Methionine+cystine | 0.75 | 0.75 | 0.75 | 0.75 | 0.90 | 0.90 | 0.90 | 0.90 | ? |

### 11.5.9.1. *Feed preparation for feeding trials*

260. The use of PPS is a crucial element of considerable local environmental significance. More extensive use of the PPS is being attempted in the present feeding trials but it is necessary to take care in using this feed to prevent it from deteriorating. Researchers visited the villages in Mbengwi to collect the material only after all other feeds had become ready for mixing. The proportions of wet matter to be used in drying on to sun-dried SP and CAS shred was important. The procedure adopted for the various dietary treatments needed to be the same to make effective comparison between treatments, and to ensure rapid drying. Detailed calculation of quantities should be made as shown in Box 2.

**Box 2. Method of preparing palm pit sediment (PPS) for use in experimental rations.**

Note: if dry matter (DM) determination is not possible, assume 90 per cent DM for sun-dried SP and CAS and 60 per cent DM for well-drained PPS.

***For broiler rations*** (Tables 27):
***Diets A & B***. (1). Determine the DM of drained PPS. (2). Determine the DM of sun-dried SP. (3). Calculate the weights of drained PPS and sun-dried SP to obtain a ratio of 10:50 as fed. (4). Prepare the necessary quantity of PPS-SP mixture for drying. (5). Grind dried PPS-SP mixture for use in the diet.

***Diet E***. (1). Determine the DM of drained PPS. (2). Determine the DM of sun-dried CAS. (3). Calculate the weights of drained PPS and sun-dried CAS to obtain a ratio of 10:50 as fed. (4). Prepare the necessary quantity of PPS-CAS mixture for drying. (5). Grind dried PPS-CAS mixture for use in the diet.

***Diet F***. (1). Determine the DM of drained PPS. (2). Determine the DM of sun-dried CAS. (3). Calculate the weights of drained PPS and sun-dried CAS to obtain a ratio of 10:36.085 as fed. (4). Prepare the necessary quantity of PPS-CAS mixture for drying. (5). Grind dried PPS-CAS mixture for use in the diet.

***Diet G***. (1). Determine the DM of a sample of drained PPS. (2). Determine the DM of sun-dried SP and CAS. (3). Calculate the weights of drained PPS and sun-dried SP and CAS to obtain a ratio of 10:30 SP+15.162 CAS as fed. (4). Prepare the necessary quantity of PPS-SP & CAS mixture for drying. (5). Grind dried PPS-SP & CAS mixture for use in the diet.

***For layer rations*** (Tables 28):
***Diet A***. (1). Determine the DM of drained PPS (found to be around 60 per cent). Determine the DM of sun-dried SP and CAS. (3). Calculate the weights of drained PPS and sun-dried SP and CAS to obtain a ratio of 10:40 SP+17.285 CAS as fed. (4). Prepare the necessary quantity of PPS-SP&CAS mixture for drying. (5). Grind dried PPS-CAS mixture for use in the diet.

***Diets D, E & F***. (1). Determine the DM of drained PPS. (2). Determine the DM of sun-dried SP. (3). Calculate the weights of drained PPS and sun-dried SP to obtain a ratio of 10:50 as fed. (4). Prepare the necessary quantity of PPS-SP mixture for drying. (5). Grind dried PPS-SP mixture for use in the diet.

***Diets G, H & I***. (1). Determine the DM of drained PPS. (2). Determine the DM of sun-dried CAS (or assume 90 % DM). (3). Calculate the weights of drained PPS and sun-dried CAS to obtain a ratio of 1.427:50 as fed. (4). Prepare the necessary quantity of PPS-CAS mixture for drying. (5). Grind dried PPS-CAS mixture for use in the diet.

For rations with PPS in Tables 29-31, similar calculations are required.

### 11.5.9.2 *Egg quality testing*:

261. In view of the use of CSC that causes yolk discolourations (Section 11.5.7.6.5) and the use of CLM as a source of yolk pigmentation egg quality testing is required in these tests. Between 7 and 8 weeks of feeding laying hens, sufficient eggs will be collected from each hen for examination of

yolks by Roche fan colour assessment and for assessing the development of brown yolk, apricot yolk and pink albumen discoulorations. Some eggs will also be kept room temperature, and some in the fridge, for examination following 1 month and 3 months of storage. Some freshly laid eggs will be opened on petri dishes and placed in a desiccator; 1 mls of ammonium hydroxide solution will be placed in the well, the lid of desiccator closed to expose yolks ammonia gas for 30 minutes. The colour of yolks will then be examined.

262. For the caged laying hen experiments, the following data will be recorded: weekly food intakes, and daily egg production (the number of eggs laid and weight of each egg laid). The number of soft-shelled and broken eggs found on cage tray, will be noted and expressed as a percentage of total number of eggs laid; also, the estimated weight of these eggs will be added to the mass of eggs laid each week. Finally, the efficiency of lay will be expressed by calculating (a) the number of eggs laid/kg feed, (b) the mass of eggs laid/kg feed, and (c) the change in body weight 0-8 weeks and 0-16 weeks.

263. For the on-farm stage of the laying hen feeding trials, the farmers poultry house will be divided into three compartments, one each for Treatments A, B and C. Total food intake per treatment and egg production (number and weight of eggs produced) will be recorded for 16 weeks.

### 11.5.9.3. *Results of feeding trials conducted during 1997-1998*

264. Only two of the proposed feeding trials (see Section 11.5.9) could be completed. Institutional changes at IRZV during the year. IRZV and IRA were combined to form the Institute of Agricultural Research for Development (IRAD) in August 1997, and the Project Manager of F0060, Dr Banser retired from IRAD in December 1998. It seemed unlikely that all the proposed work would be completed because of this; hence the decision to write up and submit the Final Technical Report at this point. However on 10th March 1998 IRAD sent in the results of the first phase of the Replacement pullet feeding trials (see paragraph 256) to NRI for statistical analysis. This phase relates to Table 34. It is therefore now expected that the second and third phases (those relating to Tables 35 and 36, will now be completed by October 1998). The results of all three phases need to be analysed as a whole since there are carryover effects of rearing diet on laying performance expected. Results will be reported in due course.

#### 11.5.9.3.1. *Broiler chick feeding trial*

265. These results are summarised in Table 37. Although growth rate with the tuber and roots-based diets were significantly lower than that with the Best commercial diet, by 8 weeks performace with the CAS-based diets were a respectable (in terms of marketability) 1.6 to 1.7 kg range. The 48 hour fermented CAS-based diet (Diet D) in fact had a significantly higher efficiency of feed utilisation (EFU) than the commercial diet. Fermentation did not produce a significant beneficial effect on broiler performance, although with SP by 8-9 weeks of feeding there was a slight improvement. The 500 g SP/kg diets were slowest to grow and had the poorest EFU. These treatments need to be continued by an additional 2-3 weeks to arrive at a weight ready for the market. At the 300 g SP/kg diet level final body weight was a respectable weight by 9 weeks.

266. The benefits of the tubers and roots-based rations however are clear when one examines the all-important parameters of Feed cost/kg liveweight gain and Feed cash outlay per day. These are crucial factors for resource poor farmers and constitute the bottom line. All the rations were more profitable than the commercial rations, and excepting the 500 g SP/kg diets by a considerable amount. For example, Diet F (Optimal ration for the Bamenda region) containing about 500 g CAS/kg cost 284 FCFA/kg liveweight gain compared to 562 for the commercial diet. For all the tubers and roots-based diet, the cash outlay per day on feed was roughly one-third that of the

commercial diet. Thus, the results show that cereal-free practical tubers and roots-based broiler rations appropriate to the circumstances of resource poor farmers can be developed.

### 11.5.9.3.2. *Laying hen feeding trial*

267. These results are summarised in Table 38. Fermentation appeared to make the diets slightly better, particularly for cassava root. However, overall these sub-optimal diets are not likely to produce high rates of egg production. It may be that their use is more appropriate when egg production has fallen to around 50 per cent in the flock, since it is dictated by their low ability to consume the feed, as was indicated from the earlier on-station caged feeding trials. However, when examning the results on a weekly basis (not shown) there was a continuing improvement in production with passing weeks. Further, it is apparent that in terms of cash outlay per egg, the roots and tubers resulted in performance that were still better than those obtained with the commercial diets. The drop in body weight is not of great concern as hens gain weight in all groups after the initial drop in body weight. Overall, under certain circumstances the use of cereal-free tubers and roots-based laying hen rations can be very profitable, although not as profitable as broiler rations.

### 11.5.9.3.3. *Replacement pullet feeding trials*

268. These results will be reported in October 1998.

**Table 37. Performance of broiler chicks fed various fermented and unfermented sweet potato (SP) and cassava (CAS) based diets in on station trial (Cameroon).**

| Treatments | A Unfer-mented SP | B 48 hr fermented SP | C Unfermented CAS | D 48 hr Ferm fented CAS | E Unfermented CAS + CLM | F Optimal diet ration unfer mented CAS | G Optimal SP (unfermented-based diet | H Best Comm. Start/Finish Rations | SEM | Signifacance (P=<) |
|---|---|---|---|---|---|---|---|---|---|---|
| *0-4 weeks:* | | | | | | | | | | |
| Weight gain (g) | 244$^{a}$ | 281$^{a}$ | 527$^{c}$ | 487$^{c}$ | 479$^{c}$ | 505$^{c}$ | 346$^{b}$ | 919$^{d}$ | 6.92 | 0.0001 |
| Food intake (g) | 616$^{a}$ | 617$^{a}$ | 937$^{cd}$ | 878$^{bc}$ | 1012$^{d}$ | 1043$^{d}$ | 786$^{b}$ | 1529$^{e}$ | 15.31 | 0.0001 |
| EFU[1] | 0.393$^{a}$ | 0.378$^{ab}$ | 0.537$^{d}$ | 0.541$^{d}$ | 0.468$^{c}$ | 0.475$^{c}$ | 0.435$^{bc}$ | 0.598$^{e}$ | 0.006 | 0.0001 |
| Total feed cost (FCFA) | 104$^{a}$ | 104$^{a}$ | 130$^{b}$ | 122$^{ab}$ | 116$^{ab}$ | 119$^{ab}$ | 110$^{ab}$ | 367$^{c}$ | 2.53 | 0.0001 |
| Feed cash outlay/day (FCFA) | 3.7$^{a}$ | 3.7$^{a}$ | 4.7$^{b}$ | 4.4$^{ab}$ | 4.2$^{ab}$ | 4.3$^{ab}$ | 3.9$^{ab}$ | 13.1$^{c}$ | 0.09 | 0.0001 |
| Feed cost/kg gain (FCFA) | 440$^{c}$ | 449$^{c}$ | 260$^{a}$ | 257$^{a}$ | 246$^{a}$ | 241$^{a}$ | 323$^{b}$ | 403$^{c}$ | 6.83 | 0.0001 |
| *0-8 weeks:* | | | | | | | | | | |
| Weight gain (g) | 1007$^{a}$ | 1088$^{a}$ | 1722$^{c}$ | 1713$^{c}$ | 1640$^{c}$ | 1724$^{c}$ | 1348$^{b}$ | 2514$^{d}$ | 23.07 | 0.0001 |
| Food intake (g) | 2677$^{a}$ | 2795$^{a}$ | 3816$^{bc}$ | 3609$^{b}$ | 3895$^{bc}$ | 4242$^{c}$ | 3443$^{b}$ | 5861$^{d}$ | 71.5 | 0.0001 |
| EFU[1] | 0.327$^{a}$ | 0.334$^{a}$ | 0.429$^{d}$ | 0.460$^{e}$ | 0.398$^{bc}$ | 0.402$^{bcd}$ | 0.374$^{b}$ | 0.427$^{cd}$ | 0.004 | 0.0001 |
| Total feed cost (FCFA) | 451$^{a}$ | 471$^{a}$ | 531$^{a}$ | 502$^{a}$ | 447$^{a}$ | 484$^{a}$ | 481$^{a}$ | 1407$^{b}$ | 11.42 | 0.0001 |
| Feed cash outlay/day (FCFA) | 8.1$^{a}$ | 8.4$^{a}$ | 9.5$^{a}$ | 9.0$^{a}$ | 8.0$^{a}$ | 8.6$^{a}$ | 8.6$^{a}$ | 25.1$^{b}$ | 0.204 | 0.0001 |
| Feed cost/kg gain (FCFA) | 516$^{d}$ | 504$^{d}$ | 325$^{b}$ | 302$^{ab}$ | 288$^{a}$ | 284$^{a}$ | 377$^{c}$ | 562$^{e}$ | 3.89 | 0.0001 |
| *0-9 weeks:* | | | | | | | | | | |
| Weight gain (g) | 1166$^{a}$ | 1333$^{ab}$ | | | | | 1555$^{c}$ | | 54.6 | 0.0496 |
| Food intake (g) | 3357 | 3601 | | | | | 4265 | | 201.5 | 0.2178 |
| EFU[1] | 0.321 | 0.320 | | | | | 0.360 | | 0.113 | 0.0008 |
| Total feed cost (FCFA) | 565$^{a}$ | 607$^{a}$ | | | | | 596 | | 34.41 | 0.7885 |
| Feed cash outlay/day (FCFA) | 9.0$^{a}$ | 9.6$^{a}$ | | | | | 9.5$^{a}$ | | 0.51 | 0.8664 |
| Feed cost/kg gain (FCFA) | 525$^{b}$ | 527$^{b}$ | | | | | 392$^{a}$ | | 9.55 | 0.0003 |

1. EFU - efficiency of food utilisation (weight gain: food intake). Comm - commercial. CLM - cassava leaf meal.

**Table 38. Performance of caged laying hens (Least squares means) fed unfermented and fermented sweet potato tuber- and cassava root-based diets in on-station feeding trial (1997-1998)**

| Dietary treatments | A | B | C | D | E | F | G | H | I | SEM | Significance (P= or <) Block | Tier | Diet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Egg production:*** | | | | | | | | | | | | | |
| Food intake (g/h/d) | $84.8^{ab}$ | $96.2^{d}$ | $142.6^{e}$ | $87.0^{bc}$ | $77.8^{a}$ | $81.7^{ab}$ | $140.3^{e}$ | $93.9^{cd}$ | $100.4^{d}$ | 0.87 | 0.0354 | 0.0001 | 0.0001 |
| Hen day production | $0.44^{a}$ | $0.48^{ab}$ | $0.77^{c}$ | $0.49^{ab}$ | $0.43^{a}$ | $0.47^{ab}$ | $0.73^{c}$ | $0.45^{a}$ | $0.52^{b}$ | 0.007 | 0.9241 | 0.0001 | 0.0001 |
| G eggs per hen d | $26.1^{a}$ | $27.9^{ab}$ | $47.2^{c}$ | $28.8^{ab}$ | $25.8^{a}$ | $27.6^{ab}$ | $44.5^{c}$ | $26.6^{a}$ | $30.3^{b}$ | 0.44 | 0.8440 | 0.0001 | 0.0001 |
| Number of eggs per kg feed consumed | $5.10^{abc}$ | $4.89^{ab}$ | $5.42^{cd}$ | $5.59^{cd}$ | $5.29^{bcd}$ | $5.75^{d}$ | $5.19^{abc}$ | $4.77^{a}$ | $5.15^{abc}$ | 0.061 | 0.8811 | 0.0006 | 0.0046 |
| Number of eggs per 1000 FCFA spent on feed | $342^{b}$ | $434^{c}$ | $271^{a}$ | $338^{b}$ | $320^{b}$ | $347^{b}$ | $260^{a}$ | $478^{d}$ | $517^{e}$ | 4.6 | 0.8988 | 0.0003 | 0.0001 |
| Mass of eggs laid per kg feed consumed | $305^{abc}$ | $287^{a}$ | $330^{cd}$ | $330^{cd}$ | $320^{bcd}$ | $335^{d}$ | $317^{bcd}$ | $282^{a}$ | $299^{ab}$ | 3.3 | 0.8068 | 0.0001 | 0.0002 |
| Mass of eggs laid per 1000 FCFA spent on feed | $2048^{b}$ | $2543^{c}$ | $1653^{a}$ | $1993^{b}$ | $1935^{b}$ | $2027^{b}$ | $1585^{a}$ | $2825^{d}$ | $2995^{d}$ | 24.1 | 0.5789 | 0.0001 | 0.0001 |
| Change in body weight 0-8 weeks | $-401^{ab}$ | $-428^{a}$ | $-130^{c}$ | $-380^{ab}$ | $-383^{ab}$ | $-421^{a}$ | $-131^{c}$ | $-389^{ab}$ | $-339^{b}$ | 7.6 | 0.2080 | 0.0001 | 0.0001 |
| Change in body weight 0-16 weeks | $-304^{abc}$ | $-305^{abc}$ | $-63^{d}$ | $-287^{bc}$ | $-293^{bc}$ | $-367^{a}$ | $-75^{d}$ | $-346^{ab}$ | $-259^{c}$ | 8.2 | 0.0581 | 0.0001 | 0.0001 |
| ***Egg quality:*** | | | | | | | | | | | | | |
| Roche colour score | $10.22^{b}$ | $9.14^{a}$ | $15.00^{f}$ | $10.61^{bc}$ | $10.61^{bc}$ | $11.78^{e}$ | - | $11.47^{de}$ | $11.00^{cd}$ | 0.08 | 0.4916 | 0.3363 | 0.0001 |
| Haugh Units | 92.6 | 89.6 | 90.1 | 91.5 | 93.2 | 91.8 | - | 90.5 | 90.1 | 0.47 | 0.7653 | 0.8802 | 0.4571 |

*Note:* Dietary treatments: A unfermented sweet potato (SP); B - fine-ground whole palm kernel (WPK), unfermented cassava root (CAS); C and G - Best commercial ration; D - coarse-ground WPK, unfermented SP; E - fine-ground WPK, unfermented SP; F - fine-ground WPK, 48 hour fermented SP; H - unfermented CAS; I - 48 hour fermented CAS. Least squares means adjust for Block and Tier effects.

### 11.5.10. *Tuber and root gritting trials*

269. This project was predicated on the availability of some kind of implement or machine to convert large quantities of SP and CAS into small particles suitable for incorporation into mixed feeds. The widespread practice of chipping tubers and roots into oblong shaped chips in developing countries where pig production is of considerable importance (eg countries of the Far East) is economically justified due to the suitability of the dried material for pigs which, unlike chickens, can chew. Production of chips requires a simple design chipping machine and it uses less energy to produce chips. The design of a chipper that slices tubers and roots into 4 mm thick oblong chips, as used in the NRI Phase 1 experiments (Section 11.4.1) does not pose any technical difficulties to local engineering firms in developing countries. For poultry production in these countries, the chips can then be ground into particle sizes suitable for incorporation into mixed mash feeds. However, where pig feeding is of lesser importance in terms of demand for feeds, it may be economically optimal to introduce tuber and root gritting technology instead, in which a higher processing cost in terms of the design of the required equipment and operation is largely offset by other benefits.

270. The aim of this adaptive research was to produce dried tuber and root particles that are about half the size of a maize grain, and which, that upon drying could be directly used in chicken rations can be readily consumed by chickens without the need for grinding into mash form. If SP and CAS could be gritted easily for direct feeding to poultry, this would bypass the grinding process in the production of poultry feeds to reduce processing costs, and would contain dustiness, reduce economic losses associated with handling meals, improve poultry performance by increasing food intakes and efficiency of food utilisation and to produce a feed more apropriate to small-scale backyard poultry production than is mash feed. It was considered that if this could be achieved there would be substantial cost savings to be made by poultry producers and the production system would also be enhanced because dustiness in feed would be reduced. This is particularly relevant consideration for small-scale poultry producers, for whom grinding not only represents an additional cost in terms of money, time and labour, but this group does not always have access to a grinding mill. Dustiness of dried roots is a major feed handling problem for agroprocessors and poses a nutritional problem for chickens which suffer respiratory problems when feeding. Thus, the dustiness of root crops, due to their low oil content, is widely acknowledged to represent a major impediment to their large-scale utilisation for poultry feeding in developing countries.

271. A preliminary feeding trial was conducted in the NRI Phase 2 Part 1 studies in which shreds produced by the J3 plate of TRS were crumbed and presented to 6-day-old broiler chicks to determine effects on food intake and growth (paragraph 84). The results were extremely encouraging for CAS in that food intake, dry matter retention, efficiency of food utlisation, and weight gain were similar to the maize controls. With SP (variety 1112) weight gain was only 8.5 per cent lower than the maize controls, although this was achieved by increasing food intakes to compensate for the lower digestibility of these grits. The results indicated that grits improved food intakes but may reduce digestibility in the case of SP but not CAS.

272. It was, however, considered that the shape and dimensions of SP and CAS grits may be an important factor affecting utilisation in terms of food intakes and digestibility. For this reason extensive gritting trials were undertaken at MRS using the TRS to determine the optimal size of SP and CAS grits that would be suitable for young birds and adult hens. TRS is a sophisticated electric food processing machine with a range of plates and grids which may be combined to produce chips, shreds and grits of various dimensions from vegetables. It was considered that the knowledge gained from this strategic research could then be adapted to develop a manual gritting machine for use by resource-poor farmers on-farm and other low-income groups interested in producing animal feeds.

273. The research had two aspects: (a) determination of the processing attributes of tubers and roots; and (b) assessment of the nutritive value of tuber and root grits.

### 11.5.10.1. *Processing attributes of tubers and roots*

274. Tuber and root processing trials were carried out to evaluation the physical and economic (as manifest in energy and time use) aspects of producing and sun-drying SP and CAS grits of different sizes using the TRS food processor. It should be stated that these trials are still not considered complete in relation to the detailed records required for basing judgements on the optimal economic procedures and equipment that should be followed Appendix 8 shows the type of studeis needed to assess the potential of using different particle shapes and sizes of tubers and roots. The aspects of the studies that were completed are presented here. Factors with practical implications that were assessed are divided into three inter-related components: (a) time required for tuber and root preparation; (b) time required to process tubers and roots in the gritting machine; and (c) time required for tuber and root grits of different sizes to dry.

#### 11.5.10.1.1. *Time required for tuber and root preparation*

275. Since tubers are not graded, it is necessary to sort out unwanted portions or wastes (these wastes are not discarded but are suitable for feeding to pigs). The tuber and root end portions are fibrous which reduce the performance of gritting in terms of throughput and causes excesssive wear and tear in the machine. Similarly, the tubers and roots need to be washed before processing since sand particles are also abrasive on the moving parts in the processor. Thus, the activities in tuber and root preparation were determined to be: (i) weighing of graded tubers and wastes; (ii) chopping with knife of large pieces to fit into the TRS food processor; (iii) removing the unwanted portions and (iv) washing or removal of dirt/soil on tubers.

276. It took two persons about 5.5 minutes to weigh 100 kg of tubers and roots and 21 minutes to prepare these for grinding. Wastes represented approximately 6.5 per cent for SP and 6 per cent for CAS (Table 39).

**Table 39. Time spent in selected activities with a labour force of one man and one woman.**

| Tuber/Root | Time taken for weighing and chipping 100 kg (minutes) | Time taken for slicing and washing 100 kg (minutes) | Wastes produced (%) |
|---|---|---|---|
| Cassava white | 5.13 | 21.77 | 6.0 |
| Cassava red | 5.03 | 22.83 | 6.0 |
| Sweet potato TIB1 | 5.99 | 18.51 | 6.5 |
| Mean time | 5.38 | 21.04 | |
| SEM[1] | 0.249 | 1.061 | |

*Note*: 1. Pooled standard error of means.

**11.5.10.1.2.** ***Time required to process tubers and roots in the TRS food processor***

277. Four kg batches of SP and CAS were processed using various TRS foor processor plate and grid combinations (Appendix 16.7). From an initial assessement, plate/grid combinations that supplied particles larger than that estimated to have potential for direct feeding to chickens were eliminated from the study. The following combinations (-denotes no use of grid) were selected for detailed evaluation plate/grid: AS3/-, AS4/-, J3/-, J4/-, J7/-, C2, C2/FS10, C2/MS8, C2/MS10, C5c/MS8, C6/MS8, C6/MS10 and C10/MS8. 4 kg of Selected shreds/chips and grits produced after sun-drying are shown in Plates 1-8. It was significant that SP samples, particularly using the J3/- and J4/- blades were sticky, elastic and shrunk in size as they dried whereas CAS samples were not sticky and did not shrink.

278. The results of these trials (Table 40) showed that it took longer to process CAS red variety through the J3/- plate than CAS (White), the throughput values being 1.84 and 1.24 min/ kg. The differences were less much less noticeable with other plate/grid combinations. However, SPTIB1 was much easier to process than CAS, taking 0.52 min/kg. The reason for the higher time needed of 0.47 min/kg for SP compared with 0.31 min/kg for CAS using AS3/- is not clear. This experiment needs to be repeated. The most efficient plate in terms of speed of processing were AS3/-, C5c/MS8, C6/MS8 and C6/MS10. Plate/grid combinations such as J3/-, C2/-, C2/FS10 and C10/MS8 were the slowest. It would appear that speed of processing was related to both water content of the tubers and roots and physico-chemical starch characteristics. SP is softer and, therefore, easier to process than CAS which is more fibrous. Another disadvantage of CAS processing is that the larger roots compared with SP requires to be cut with a machete into smaller sizes for insertion into the processing machine, whereas for SP most long tubers can be inserted whole while rounder ones can be easily cut with a knife. The greater thickness of CAS peel also slows its processing throughput in comparison with SP.

**Table 40. Evaluation of the performance of TRS plate/grid combinations for the processing of sweet potato and cassava into grits.**

| Plate/grid combination | Time for tuber and root varieties (min/kg) CASRed | CASWht | SPTIB1 | Mean time(min/kg) for plate/grid | SEM[1] |
|---|---|---|---|---|---|
| AS3/- | - | 0.31 | 0.47 | 0.39 | 0.06 |
| AS4/- | - | 0.31 | 0.30 | 0.31 | 0.01 |
| J3/- | 1.84 | 1.24 | 0.52 | 1.20 | 0.31 |
| J4/- | 0.59 | 0.59 | 0.30 | 0.49 | 0.08 |
| J7/- | - | 1.56 | 1.25 | 1.40 | 0.11 |
| C2/- | 1.43 | 1.39 | 0.85 | 1.22 | 0.15 |
| C2/FS10 | 1.25 | 1.32 | 1.17 | 1.25 | 0.04 |
| C2/MS8 | - | 0.78 | 0.62 | 0.70 | 0.06 |
| C2/MS10 | 0.93 | 1.17 | 0.64 | 0.91 | 0.13 |
| C5c/MS8 | - | 0.31 | 0.30 | 0.31 | 0.01 |
| C5c/MS10 | 0.49 | 0.40 | 0.32 | 0.40 | 0.04 |
| C6/MS8 | - | 0.31 | 0.30 | 0.31 | 0.01 |
| C6/MS10 | - | 0.30 | 0.31 | 0.31 | 0.01 |
| C10/MS8 | - | 1.56 | 0.62 | 1.09 | 0.33 |
| Means | 1.09 | 0.83 | 0.57 | | |
| SEM | 0.19 | 0.13 | 0.08 | | |

**Note**: 1 Pooled standard error of means. CASRed Cassava Red; CASWht Cassava White; SPTIB1

11.5.10.1.3. *Time required for tuber and root grits of different sizes to dry*

279. The rationale for this component was that the optimal grit size that minimsed labour requirements were those that could be sun-dried to below 13 per cent moisture within one day (8.00 am to 6.00 pm) during the dry season in the project field area so that operators did not have to gather-in semi-dried material at the end of a day only to have to spread it out in the sun the following day to finish off the drying. Drying rate is, however, also related to the density at which the grits are spread. The first stage was therefore to determine the optimal loading density. For this experiment only the AS3 plate of TRS was used. Four kg batches of each tuber and root variety were processed and sun-dried at the loading densities of 1.0, 1.1, 1.3, 1.6, 2.0, 2.7, 4.0, and 8.0 kg per metre square. The processed tubers were spread evenly on a navy blue tarpaulin in the sun (Appendix 14, Plates 1-2). The experiment was repeated threee times on separate days, beginning at 8.00 am. Temperatures over the grits varied from 20$^{o}$C to 42$^{o}$C, while relative humidity varied between 40 per cent and 86 per cent. At 6.00 pm, samples were taken for determination of dry matter in a Gallenkamp force-draft oven set at 105$^{o}$C.

280. The results of these drying trials are shown in Table 41. As expected the dry matter content increased with a reduction in loading density. SP dried quicker than CAS for this particular plate/grid combination despite the former's higher water content in the fresh state. CAS and SP behaved differently during drying, the former not changing in size but the SP shrivelling into a smaller size, and CAS producing more dust than SP. Wear and tear of the cutting blade on the TRS were also more severe when gritting CAS than SP due the higher dry matter and fibrous nature of the former. Between the two CAS varieties there were also differences, which may be directly related to their water content in the fresh state (Appendix 4, Table 24).

**Table 41. Dry matter content (per cent) of tuber and root shreds produced from AS3 plate of TRS after one day (8 am to 6 pm) of drying.**

| Tuber/Root | Loading density (kg/m$^2$)/Floor surface area for spreading 4 kg (m$^2$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Variety | 1.0/4.0 | 1.1/3.5 | 1.3/3.0 | 1.6/2.5 | 2.0/2.0 | 2.7/1.5 | 4.0/1.0 | 8.0/0.5 |
| CASRed | 8.2 | 9.9 | 11.0 | 14.5 | 22.6 | 24.2 | 23.1 | 29.2 |
| CASWht | 10.9 | 9.3 | 10.6 | 15.5 | 17.7 | 25.3 | 27.3 | 35.9 |
| SPTIB1 | 9.3 | 7.1 | 6.9 | 9.6 | 11.1 | 15.3 | 15.8 | 13.3 |
| Means | 9.5 | 8.8 | 9.5 | 13.2 | 17.1 | 21.6 | 22.1 | 26.1 |
| SEM | 0.64 | 0.7 | 1.07 | 1.49 | 2.72 | 2.59 | 2.74 | 5.47 |

**Note**: 1 Pooled standard error of means. CASRed Cassava Red; CASWht Cassava White; SPTIB1.

11.5.10.2. *Assessment of the nutritive value of tuber and root grits*

281. This study evaluated the potential for feeding SP and CAS grits of different dimensions to broiler chickens of different ages. Two feeding trials were conducted using the same batch of broiler chicks to test the effect of using grits from SP and CAS on broiler performance.

### 11.5.10.2.1. *Design of broiler chick feeding experiment*

282. Two hundred and eighty five unsexed broiler chicks were obtained from SPC-Cameroon and fed on a commercial mash diet. Three diets were formulated (Tables 42 and 43) a CAS (variety White)-based diet (A), a SP (variety 1112)-based diet, and a maize-based diet. At 9 days of age birds were allocated to 10 experimental treatments (5 CAS plate/grid combinations, 4 SP plate/grid combinations, and one maize-based ration) using 2 replicates per treatment, with each replicate consisting of between 14 and 17 chicks. The mean initial chick liveweights for different treatments were equalised. The CAS-based groups represented grits using the following TRS plate/grid combinations: J4/-, J7-, C2/MS8, J3/-, C2/MS10. The SP-based groups represented grits produced by J7/-C2/MS8, J3/- and C2/MS10 combinations. These combinations were selected after examination of the grits (Plates 1-8) showed that grits of other dimension were not suitable for direct feeding due to their large size.

283. At 30 days of age birds were randomised and fed to commercial feed. At 40 days of age birds were allocated to 26 experimental treatments, (12 CAS plate/grid combinations, 13 SP plate/grid combinations, and one maize-based diet) using 2 replicates for each CAS-and SP-based treatments (except for SP-C2/FS10 and SP J7/- which had only one replicate) and 3 replicates for maize-based diets, with each replicate consisting of 4 chicks. The CAS-based groups represented grits using the following TRS plate/grid combinations: AS3/-, C6/MS10, J4/-, C2/-, C6/MS8, J7/-, C2/MS8, J3/-, C2/FS10, C2/MS10, C5/MS10, and C5/MS8). The SP treatments included these combinations and C10/MS8. The mean initial chick liveweights for different treatments were equalised.

### 11.5.10.2.2. *Results of broiler chick feeding experiment*

284. The results of these feeding trials are summarised in Tables 44-47. These showed that there were major differences in the performance of chicks fed SP and CAS grits produced by different TRS plate/grid combinations. In general, bird performance was significantly better with CAS-based diets than the maize-based diet and was lowest with the SP-based diets, reflecting the higher digestibilities of the diets. However, within the CAS and SP-based diets there were wide differences between treatments relecting the feeding value of grits of different sizes. Significant interactions of dietxplate/grid combination for weight gain, food intake and food conversion efficiency for chicks of both ages showed that the raw materials differ such that the same plate/grid combination may not be be optimal for CAS and SP. For SP, the results were best with the J3 and C2/MS10 plate/grid combination, but results of feeding trials with grits were not good as with CAS due it appears to the lower digestibility (confirming the results obtained in the Phase 2 NRI trial). However, this effect may be offset by the high food intakes associated with grits so that at the small farmer level it would still be profitable for farmers to adopt the gritting technology for SP. It should also be noted that some of the high food intakes in particular groups were related to excessive spillage due to the large particle sizes. For CAS, C2/MS8 appeared to give the young chicks whereas C2/MS10 and J3/- combinations was best for adult chicks. Thus, for CAS there were significant benefits to be had by gritting the roots and tubers, although beyond a certain size of grits feed spillage was high so that the costs of feed wastage outweighed the benefits. Further, the benefits were greater for young chicks between 9 and 30 days of age as shown in Table 38; however, a point to note in these trial is that mean treatment liveweights were equalised before the start of the old broiler trials (40-61 days) so that it would be expected that the benefits of gritting for CAS grit fed chicks will be continued through to slaughter weight in normal feeding situations.

**Table 42. Composition of the broiler starter diets (9-30 days) used in the tuber and root grit experiment (% unless otherwise stated).**

| Diets | Sweet potato-based | Cassava-based | Maize-based (control) |
|---|---|---|---|
| ***Ingredients:*** | | | |
| Fishmeal | 10.5 | 6.5 | 9.5 |
| Oyster shells | 0.6 | 0.6 | 0.6 |
| Bone meal | 1.0 | 1.2 | 1.5 |
| Blood meal | 1.5 | 1.5 | 1.5 |
| Soyabean meal | 16.0 | 33.0 | 17.0 |
| Salt | 0.3 | 0.3 | 0.3 |
| Methionine-DL | 0.2 | 0.3 | 0.2 |
| Palm oil | 5.0 | 5.7 | 0 |
| Rice bran | 12.0 | 0.9 | 0 |
| Maize | 12.9 | 10.0 | 62.4 |
| Cassava White | 0 | 40.0 | 0 |
| Sweet potato 1112 | 40 | 0 | 0 |
| *Total* | 100 | 100 | 100 |
| ***Calculated analyses:*** | | | |
| Crude protein | 19.44 | 22.74 | 20.98 |
| AME (MJ/kg) | 12.07 | 13.60 | 12.12 |
| Calcium | 1.12 | 1.06 | 1.19 |
| Phosphorus | 0.8 | 0.69 | 0.86 |
| Lysine | 1.25 | 1.45 | 1.24 |
| Methionine+cystine | 1.12 | 1.2 | 1.16 |
| Salt | 0.56 | 0.46 | 0.53 |
| Cost (FCFA/kg) | 240.63 | 263.12 | 242.3 |

*Note*: The gritting trials were not conducted with a full knowledge of the nutritional composition of the ingredients so that diets were not nutritionally-balanced. Diets were also not formulated to least-cost.

**Table 43. Composition of the broiler finisher diets (40-61 days) used in the tuber and root grit experiment (% unless otherwise stated).**

| Diets | Sweet potato-based | Cassava-based | Maize-based (control) |
|---|---|---|---|
| ***Ingredients:*** | | | |
| Fishmeal | 10.0 | 10.0 | 7.5 |
| Oyster shells | 0.6 | 0.6 | 0.6 |
| Bone meal | 1.5 | 1.5 | 2.0 |
| Blood meal | 2.0 | 2.0 | 2.0 |
| Soyabean meal | 12.0 | 23.0 | 11.0 |
| Salt | 0.3 | 0.3 | 0.3 |
| Methionine-DL | 0.1 | 0.1 | 0.1 |
| Palm oil | 7.0 | 6.0 | 1.5 |
| Rice bran | 12.0 | 0 | 0 |
| Maize | 14.5 | 16.5 | 66.0 |
| Cassava White | 0 | 40.0 | 0 |
| Sweet potato 1112 | 40.0 | 0 | 0 |
| Palm kernel cake | 0 | 0 | 9.0 |
| *Total* | 100 | 100 | 100 |
| ***Calculated analyses:*** | | | |
| Crude protein | 17.79 | 21.32 | 18.62 |
| AME (MJ/kg) | 12.59 | 14.09 | 12.62 |
| Calcium | 1.24 | 1.26 | 1.25 |
| Phosphorus | 0.82 | 0.76 | 0.80 |
| Lysine | 1.15 | 1.37 | 1.03 |
| Methionine+cystine | 0.95 | 1.06 | 0.95 |
| Salt | 0.55 | 0.53 | 0.48 |
| Cost (FCFA/kg) | 231.77 | 247.01 | 219.64 |

*Note*: see footnote in Table 1

285. The conclusion from these tuber and root gritting trials were that young and old broiler chicks performed well on tuber and root grits of most of the dimensions tested. The use of grits is, therefore, preferable to mash feed in developing practical tuber and root-based poultry feeding

systems. The grits produced by a machine must be such that day old chicks can consume it, or else the ration will have to be switched after some time, which can cause confusion and additional work for poultry producers. Overall, researchers agreed to a manual gritter was required that could produce grits of 4mm *x* 3mm *x* 2mm amounting to 40-60 per cent of the material with the remaining particles being smaller than this and ideally some ground feed also being produced which will be consumed by the day-old chicks.

**Table 44. Summary of broiler performance on tuber and root grits produced by various TRS plate/grid combinations.**

| TRS Plate-grid combination | Young broilers (9-30 days of age) | | | Old broilers (40-61 days of age) | | |
|---|---|---|---|---|---|---|
| | *Weight gain (g)* | *Food intake (g)* | *FCR* | *Weight gain (g)* | *Food intake (g)* | *FCR* |
| SP-AS3/- | - | - | | 1027 | 3206 | 3.123 |
| SP-J3/- | 465 | 843 | .885 | 944 | 3017 | 3.205 |
| SP-J4/- | - | - | | 986 | 3190 | 3.242 |
| SP-J7/- | 416 | 736 | 1.771 | 1006 | 3250 | 3.234 |
| SP-C2/- | - | - | - | 963 | 3384 | 3.526 |
| SP-C2/FS10 | - | - | - | 964 | 3049 | 3.234 |
| SP-C2/MS8 | 390 | 847 | 2.154 | 1085 | 3501 | 3.221 |
| SP-C2/MS10 | 457 | 806 | 1.768 | 927 | 3330 | 3.605 |
| SP-C5c/MS8 | - | - | - | 1035 | 3162 | 3.056 |
| SP-C5c/MS10 | - | - | - | 960 | 3151 | 3.288 |
| SP C6/MS8 | - | - | - | 1114 | 3015 | 2.698 |
| SP-C6/MS10 | - | - | - | 1021 | 3282 | 3.220 |
| SP-C10/MS8 | - | - | - | 920 | 3069 | 3.355 |
| CAS-AS3/- | - | - | - | 1121 | 2950 | 2.628 |
| CAS-J3/- | 535 | 716 | 1.341 | 1373 | 3234 | 2.353 |
| CAS-J4/- | 547 | 736 | 1.404 | 1216 | 2955 | 2.434 |
| CAS-J7/- | 564 | 759 | 1.319 | 1183 | 2979 | 2.524 |
| CAS-C2/- | - | - | - | 1059 | 2607 | 2.463 |
| CAS-C2/FS10 | - | - | - | 1121 | 2824 | 2.517 |
| CAS-C2/MS8 | 632 | 802 | 1.291 | 1089 | 2824 | 2.593 |
| CAS-C2/MS10 | 607 | 793 | 1.337 | 1225 | 2941 | 2.409 |
| CAS-C5c/MS8 | - | - | - | 1139 | 2859 | 2.509 |
| CAS-C5c/MS10 | - | - | - | 1064 | 2667 | 2.509 |
| CAS-C6/MS8 | - | - | - | 958 | 2690 | 2.896 |
| CAS-C6/MS10 | - | - | - | 1111 | 2926 | 2.636 |

Table continued next page

Table continued from previous page

| | | | | | | |
|---|---|---|---|---|---|---|
| ***Diet Means*** | | | | | | |
| SP | 432$^{a}$ | 808$^{b}$ | 1.895$^{b}$ | 996$^{b}$ | 3200$^{b}$ | 3.231$^{a}$ |
| CAS | 577$^{b}$ | 761$^{a}$ | 1.339$^{a}$ | 1138$^{a}$ | 2871$^{a}$ | 2.539$^{b}$ |
| Maize (ground) | 529$^{b}$ | 744$^{a}$ | 1.556$^{a}$ | 1247$^{a}$ | 2876$^{a}$ | 2.321$^{b}$ |
| SEM | 12.6 | 10.5 | 0.30 | 15.4 | 29.7 | 0.036 |
| *Significance* (P=<) | 0.0002 | 0.0898 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| ***Plate/grid Means*** | | | | | | |
| AS3/- | - | - | | 1074 | 3078 | 2.876 |
| J3/- | 500 | 780 | 1.614 | 1159 | 3126 | 2.779 |
| J4/- | 547 | 736 | 1.404 | 1101 | 3072 | 2.838 |
| J7/- | 490 | 748 | 1.545 | 1094 | 3114 | 2.879 |
| C2/- | - | - | - | 1011 | 2996 | 2.995 |
| C2/FS10 | - | - | - | 1043 | 2936 | 2.875 |
| C2/MS8 | 511 | 824 | 1.723 | 1087 | 3162 | 2.907 |
| C2/MS10 | 532 | 799 | 1.553 | 1076 | 3135 | 3.007 |
| C5c/MS8 | - | - | - | 1087 | 3011 | 2.783 |
| C5c/MS10 | - | - | - | 1012 | 2909 | 2.899 |
| C6/MS8 | - | - | - | 1036 | 2852 | 2.797 |
| C6/MS10 | - | - | - | 1066 | 3104 | 2.928 |
| C10/MS8 | - | - | - | 920 | 3069 | 3.355 |
| SEM | 24.2 | 11.3 | 0.0802 | 19.4 | 41.2 | 0.086 |
| *Significance* (P=<) | 0.9567 | 0.1690 | 0.8495 | 0.8855 | 0.9404 | 0.9946 |

**Notes**: SEM - Pooled standard error of means. Plate/grid combinations refer to TRS Dito Sama Food Processor (refer to Plates 1-8 and Appendix 7 for the appearance of grits. Flakes were generally considered unsuitable. FCR - Feed Conversion Efficiency (food intake:weight gain). Number of replicates per diet: Young chicks - A 10, B 8, G 2; Old chicks - A 24, B 26, G 4.

**Table 45. Significance of main effects on broiler chick performance using cassava and sweet potato grits (analysis of covariance).**

| **Factors** | **Young broilers (9-30 days of age)** | | | **Old broilers (40-61 days of age)** | | |
|---|---|---|---|---|---|---|
| | ***Weight gain (g)*** | ***Food intake (g)*** | ***FCR*** | ***Weight gain (g)*** | ***Food intake (g)*** | ***FCR*** |
| ***Effect of diet*** | | | | | | |
| SP | 433$^{a}$ | 809 | 1.897$^{b}$ | 997$^{b}$ | 3204$^{b}$ | 3.231$^{b}$ |
| CAS | 575$^{b}$ | 759 | 1.336$^{a}$ | 1137$^{a}$ | 2866$^{a}$ | 2.540$^{a}$ |
| Maize (ground) | 532$^{b}$ | 748 | 1.560$^{a}$ | 1250$^{a}$ | 2886$^{a}$ | 2.320$^{a}$ |
| SEM | 16.4 | 13.4 | 0.039 | 21.2 | 38.9 | 0.051 |
| *Significance* (P=<) | | | | | | |
| IWT (covariate) | 0.5433 | 0.3067 | 0.6667 | 0.0677 | 0.0042 | 0.9613 |
| Diet | 0.0004 | 0.0778 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| ***Effect of plate/grid*** | | | | | | |
| IWT (covariate) | 0.1815 | 0.6693 | 0.3928 | 0.0001 | 0.1300 | 0.8710 |
| Plate/grid | 0.7790 | 0.2070 | 0.7439 | 0.9112 | 0.9590 | 0.9951 |

*Notes*: SEM - Pooled standard error of means. Initial weight (IWT) for Diets (g): Young chicks - A 114, B 115, G 117; Old chicks - A 984, B 995, G 989.

**Table 46. Least squares means of data from broiler chick feeding trials with cassava and sweet potato grits (excludingTreatments A-C and B-M for factorial analysis of variance).**

| **TRS Plate/grid combination** | **Young broilers (9-30 days of age)** *Weight gain (g)* | *Food intake (g)* | *FCR* | **Old broilers (40-61 days of age)** *Weight gain (g)* | *Food intake (g)* | *FCR* |
|---|---|---|---|---|---|---|
| SP-AS3/- | - | - | | 1012 | 3152 | 3.119 |
| SP-J3/- | 466 | 852 | .902 | 938 | 2998 | 3.204 |
| SP-J4/- | - | - | | 980 | 3171 | 3.241 |
| SP-J7/- | 415 | 726 | 1.753 | 1000 | 3231 | 3.232 |
| SP-C2/- | - | - | - | 973 | 3416 | 3.528 |
| SP-C2/FS10 | - | - | - | 975 | 3087 | 3.237 |
| SP-C2/MS8 | 390 | 842 | 2.146 | 1097 | 3542 | 3.225 |
| SP-C2/MS10 | 458 | 822 | 1.795 | 919 | 3302 | 3.602 |
| SP-C5c/MS8 | - | - | - | 1064 | 3264 | 3.064 |
| SP-C5c/MS10 | - | - | - | 964 | 3166 | 3.290 |
| SP-C6/MS8 | - | - | - | 1111 | 3005 | 2.697 |
| SP-C6/MS10 | - | - | - | 1013 | 3255 | 3.218 |
| CAS-AS3/- | - | - | - | 1113 | 2922 | 2.626 |
| CAS-J3/- | 535 | 720 | 1.348 | 1365 | 3204 | 2.351 |
| CAS-J4/- | - | - | - | 1213 | 2945 | 2.433 |
| CAS-J7/- | 564 | 759 | 1.320 | 1184 | 2982 | 2.525 |
| CAS-C2/- | - | - | - | 1056 | 2597 | 2.462 |
| CAS-C2/FS10 | - | - | - | 1118 | 2813 | 2.516 |
| CAS-C2/MS8 | 631 | 790 | 1.271 | 1081 | 2795 | 2.591 |
| CAS-C2/MS10 | 607 | 790 | 1.334 | 1219 | 2922 | 2.408 |
| CAS-C5c/MS8 | - | - | - | 1136 | 2848 | 2.509 |
| CAS-C5c/MS10 | - | - | - | 1076 | 2709 | 2.512 |
| CAS-C6/MS8 | - | - | - | 959 | 2693 | 2.896 |
| CAS-C6/MS10 | - | - | - | 1125 | 2976 | 2.640 |
| RMSE | 43.0 | 18.8 | 0.095 | 95.7 | 178.2 | 0.263 |
| *Significance* (P=<) | | | | | | |
| IWT | 0.9508 | 0.1955 | 0.6404 | 0.1037 | 0.0044 | 0.8753 |
| Diet (D) | 0.0003 | 0.0027 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Plate/grid (P/G) | 0.6036 | 0.0039 | 0.1494 | 0.7655 | 0.4361 | 0.9736 |
| P/GxD interaction | 0.1289 | 0.0037 | 0.0459 | 0.0396 | 0.0601 | 0.1331 |

*Notes*: RMSE - Root Mean Square Error.

**Table 47. Cost-effectiveness of feeding young broilers with SP and CAS grits in relation to a maize based control diet.**

| **Diet** | **9-30 days-old broilers** LWT gain | FCR | Feed cost/kg LWT gain | **40-61 days-old broilers** LWT gain | FCR | Feed cost/kg LWT gain |
|---|---|---|---|---|---|---|
| CAS-based (A) | 577 | 1.34 | 351 | 1138 | 2.54 | 627 |
| SP-based (B) | 432 | 1.90 | 456 | 996 | 3.23 | 748 |
| Maize-based control | 529 | 1.56 | 378 | 1247 | 2.32 | 510 |

### 11.5.10.3. *Implications of the findings from tuber and root gritting trials*

286. The project concept was predicated on the availability of a machine to at least produce chips from tubers and roots. Lack of availability of a machine that could produce the type of grits that chickens can consume was the reason that the project ration development was conducted using ground feeds. The development of a chipping machine does not pose any technical difficulties (paragraph 248). The engineering firm CAIPCIG which was identified in the prefeasibility study in 1994 (paragraph 68) had indicated that it could produce a low-cost manual chipping machine. The RRA also revealed that MRS also already had a small diesel-powered cassava grater developed in an earlier research project on '*garri*' production (paragraphs 59-60). PRTC also had two manual cassava graters (Type G/H Machine Nr1, and costing 60,000 FCFA) which were designed by the Director, Mr Hans Ichar. These machines could be adapted to using electricity or be converted to diesel-powered operation. However, grating tubers and roots is an energy-intensive process requiring much labour, and the throughput achieved in the gritting machine was considered too slow for producing large quantities of poultry feeds (paragraphs 248-249). However, there was scope for designing suitable cutting blades to the replace existing the grating plates on these machines for poultry feed production.

287. Although more research remains to be conducted to determining the economic potential of different SP and CAS grits of different dimensions by assessing their sun-drying characteristics, texture, dustiness, clumpiness, ease of crumbling of grits (Appendix 16.8), the implications of results obtained thus far for project work concerned the use of technology for producing mash feed, and the need to develop a manual tuber and root gritting machine for on-farm use.

#### 11.5.10.3.1. *Implications for developing poultry rations using ground tubers and roots*

288. The first on-station feeding trials (Section 11.5.7.1) were conducted using tubers and roots produced by the J3 plate of TRS because the results of these gritting trials were not available until much later. However, as Table 33 shows this TRS plate consumes considerable energy as indicated by the slow throughput. It was, therefore, not considered a practical option in economic terms, and its use in the project work was also discontinued. For large scale processing, the AS3 and AS4 plates combinations were considered suitable, with the latter being selected for project use due to its faster throughput of SP compared with AS3. On the basis of the drying trials, the loading density selected for most of the studies in the project was 1.3 $kg/m^2$. If chipping technology is considered, a chipper that produced AS4 type of shreds may be optimal for SP and CAS (Plates 2 and 7).

#### 11.5.10.3.2. *Implications for the development of manual gritting machine for on-farm use*

289. The tuber and root gritting investigations conducted using the TRS electric food processor demonstrated the benefits of the gritting technology. However, sophisticated electric food processors of the type used in this study are not generally available in developing countries and even if they were to become available they would be outside the ability of resource-poor farmers to acquire. The gritting technology, therefore, needs to be adapted to the resources and constraints of the target beneficiaries.

### 11.5.10.4. *Specifications for the manual gritting machine*

290. In considering options for the design of a suitable gritter several of the research findings were important. First, the trials identified different optimum sizes and shapes for SP and CAS (see paragraphs 72-77). Further, CAS and SP behaved differently during drying, the former not changing in size but the SP shrivelling into a smaller size, and CAS producing more dust than SP. Wear and tear of the cutting blade on the TRS were also more severe when gritting CAS than SP due the higher

dry matter and fibrous nature of the former. There was also the need to ensure that SP and CAS grits could be sun-dried within a day in the weather conditions prevailing in the western highlands. The latter objective is important to save time and labour inputs that would otherwise be required if operators had to gather and bring semi-dried material indoors at the end of each day only to take it out and spread it in the sun the following day to complete the drying process. Chickens of all ages needed to be able to utilise the grits produced from a single technology.

291. The different processing and drying characteristics of SP and CAS suggested that for regions where both raw materials were available for animal feeding, the gritting machine should be equipped with inter-changeable cutting blades for SP and CAS. Of the two commodities, SP proved to pose more utilisation problems in terms of digestibility and intakes, so that the griiting machine would focus on the processing of SP. This commodity also deserves priority attention in blade design due to the fact that chicks were observed to be able to cope with a wider range of CAS than of SP grit sizes. Whatever was successful with SP should also work well with CAS, but if efforts were made to optimise with CAS, there was a possiblity the product resulting from the same gritter when SP is processed may not be suitable. Overall, the findings indicated that the comb-cutter should be modified such that 40-60 per cent of the grits were of 4mm *x* 3mm *x* 2mm dimensions, with the remainder being smaller and some particles would emerge as fine particles. The finer particles would be consumed by the day-old chicks, which would then gradually consume the larger particles as they grew larger. Thus, The dimensions specified appeared optimal for combined SP and CAS in terms of meeting the nutritional requirements of chickens.

292. The desired specifications for grits was not considered possible with the existing design of the graters at MRS and PRTC. For example, to contain dustiness a clean cut on tubers and roots rather than a grating action might be more appropriate when designing the machine. It was, therefore, essential to design a gritting machine specially for the project. Since the development of a suitable gritting machine has reached the final stages, it is of vital importance that the specifications take account gender and safety considerations on height, weight, positions of various bars/handles. Socio-cultural factors as they relate to rural women eventually expected to operate the gritting machine, need to be considered in deciding whether the machine should be hand- or pedal-operated. The design of this machine should, therefore, be conducted with the participation of some of women groups in the field.

**11.5.10.4.1** ***Manual gritting machine prototype development during 1994-1997***

293. The first step taken in this project to developing a prototype manual cutting blade was to approach an engineering firm, CAIPCIG in Bamenda. The project work was discussed with the engineering firm CAIPCIG (in Bameda) who examined the grits and shreds produced by the TRS machine with a view to developing a suitable pilot cutting blade that would produce grits from SP and CAS that were about half the size of a maize grain. However, this firm did not have the necessary finances for the research required despite being offered a substantial sum from project funds as a top-up. Subsequently, the PRTC (the NGO participant in the on-farm trials) agreed to assist the project, this organisation having access to both engineering, technical and financial resources and having previous experience of developing agricultural implements for small-scale farmers.

294. By January 1996, PRTC used the basic design of the cassava graters (paragraph 266) to produce was a simple chipper which sliced SP and CAS into oblong 4 mm thickness chips, similar to those used in the NRI Phase 1 studies (Section 11.4.1., Appendix 14). The design of the machine did not pose any technical difficulties but the chips produced need to be ground further for use as mash feeds. Further, the rotating blade proved too heavy for manual operation, especially for women who were mostly expected to operate it.

295. PRTC modified this prototype by September 1996. For the second prototype, the engineer opted for a design in which four comb-type cutters were screwed onto the rotating disc at an

angleover a slit in the disc so that grits were produced. This machine had considerable potential for application as the grits could be sun-dried within a day. However, the design was still not suitable for producing the size of grits that chickens of all ages can consume wihout further grinding. The machine also still proved too heavy for on-farm operation by women. Further development of this machine was required

#### 11.5.10.4.2 *Manual gritting machine prototype developed during 1997-1998*

296. LPP approved funds to finalise the developmeng of this manual gritting in February 1997. Steps were taken to ensure that there was genuine participation by women groups before the prototype is finalised. The technical problems of producing grits directly from fresh tubers and roots that upon sun-drying would be of a size that could be consumed by chickens were too great. After numerous trials, it was decided to develop a separate gritter (Pioneer gritter - see photographs) which would crush sun-dried SP and CAS chips into small particles suitable for chickens to consume.

297. The performance of the machine was evaluated also in terms of the ability of chicks of different ages to consume the gritted particles (Table 48). The results were considered satisfactory. Feeding trials will be conducted in the future using these grits to deterimine the long term potential of this method of producing feed and feeding it to chickens.

**Table 48. Preliminary observations on the percentage of particles retained by various sieves of the manual prototype chipper and gritter machine products.**

| Sieve size (mm) | Percentage of particles retained | | Observations |
|---|---|---|---|
| | Sweet potato | Cassava white | |
| >6.30 | 4.69 | 2.81 | Particles too large for adult chickens |
| >4.0 - ≤6.3 | 20.76 | 15.95 | Particles fit for adult chickens |
| >3.15 - ≤4.0 | 13.72 | 16.28 | Particles fit for adult chickens |
| >2.5 - ≤3.15 | 16.25 | 12.66 | Particles fit for 5 day-old chicks |
| ≤2.5 | 44.58 | 52.30 | Paricles fit for day-old chicks |

298. The protoype of the manual chipper and manual gritter had the NRI/ODA/IRZV logos. It will be kept at MRS and the design will be available for any person wishing to copy and producing tuber and root grits. It is expected that CAIPCIG may eventually become involved in the manaufacturing and marketing of this machine if sufficient demand is generated following the dissemination of project outputs.