12. PROJECT OUTPUTS

299. The project outputs were as follows.

12.1. *Cereal-free poultry rations*

12.1.1. *Sweet potato-based broiler and layer rations*

300. Some cereal-free SP-based ration was developed. These were more profitable than commercial rations. However, SP-based layer rations may only be suitable when egg production rate has fallen to about 50 per cent hen day.

12.1.2. *Cassava-based broiler and layer rations*

301. Numerous cereal-free CAS-based broiler chicken rations were developed that proved to be more profitable than the maize-based commercial ration in the production systems of small-scale resource-poor farmers in project field site. Also of significant benefit for resource-poor farmers was that cash outlay per day with these rations were generally one-third that with the commercial rations.

302. Whilst there remains the possiblity of improving these rations in terms of their production potential and profitability, the rations need to be promoted for adoption by appropriate dissemination. CAS has greater potential for use as poultry feed due to better chicken performance due to higher digestibility. Further, the dry matter of SP is lower than that of CAS generally, so that processing costs are lower with the former.

303. However, it should be appropriate at this stage to state that once optimal rations for different classes of poultry have been developed the figures need to be rounded up to make them farmer-friendly so that resource-poor farmers without access to weights and balances can use them on a routine basis. After rounding up the figures, the measures in weights should be changed to measures in the type of 'buckets' and 'scoops' that the particular user has access to. Such rounding up and conversion of weights to measures that the user can use is likely to lead to nutrient imbalances in the ration so that much care will be required to minimise these. However, this activity represents the final stage of adaptive research that the present project needs to implement when the results of the current research (Section 11.5.11) are available.

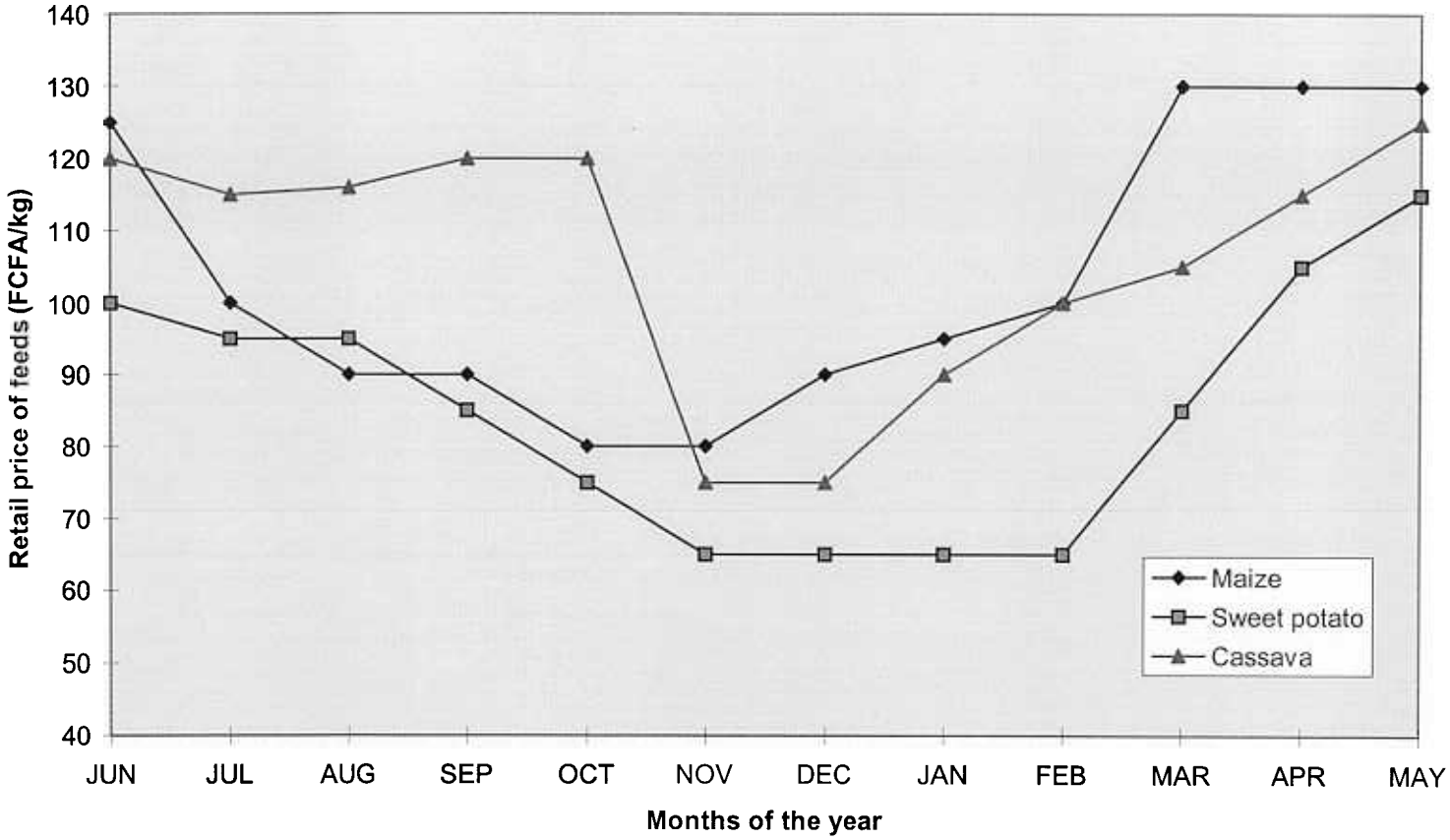
12.1.3. *Effect of price instability on project outputs*

304. This project commenced at a time of economic depression in Cameroon in 1993-1994 (Silverside, 1993) and the prices used in determinig the relevance of project research were based on those. Prices were more or less stable during the next two years at low levels, and the seasonal fluctuations were for SP, CAS and maize were followed during 1995 (Figure). The montlly fluctuations during the stable price period was studied and found to be consistent with the project concept of gritting, sun-drying and storing the tubers and roots in the dry season, which was not only technically most appropriate but also coincided with the time when the price advantage relative to maize was high.

305. However, during 1996-1997 large fluctuations were evident. For example, in 1994, WPK retailed in the rural areas at only 25 FCFA/kg but in 1997 the price increased to 125 FCFA/kg, reflecting an increase in demand for WPK. The recent increase in the general price level appears to be due to an economic recovery arising from the market liberalisation policies pursued by the government in recent years. IRZV researchers were concvinced that the WPK was unlikely to return to the old price, so the feeding trials designed for 1997 were based on the new price of this commodity.

306. Assessment of the outputs of the project must always be made with reference to relative prices of the major animal feed commodities (listed in Appendix 16.6). The project should aim to evaluate a range of rations which may be applicable under different price structure or to meet the different situations encountered by resource-poor production systems. Thus, Male Farmer B enquired whether he could use '*garri*' in poultry feeds because occasionally he is offered a large quantity of it at a knock down price that another ecnomic operator wished to dispose. Brewery dried grains and palm kernel meal from a industrial scale production were other items mentioned. Similarly, Male Farmer A enquired about optimal rations in down graded whole groundnuts and whole soyabeans could be similarly used. The essential point here is that in order to assist development the advice should be based on an approach that may be termed 'optimisation with options'. Small-scale poultry producers need a range of rations to suit different pricing situations commonly encountered in different seasons, so that they are able to respond to new prices by moving from one ration to the other. Currently, they may simply replace one ingredient with another which results in loss of production and a waste of resources.

Figure 2. Changes in the price of sweet potato tuber, cassava root and maize in the project field site region during 1995-1996 (on a dry matter basis).



12.2. *Tuber and root gritting machine*

307. The project concept is predicated on the development of a suitable equipment for red ucing fresh tubers and roots into particles sizes that can be sun-dried quickly under field conditions. A chipping machine was developed which is ready for transfer if it is decided to grind the sun-dried materials before incorporation into feeds. However, the project also developed a gritter to grit sun-dried CAS and SP chips. These produce grits that may be directly incorporated into feeds to reduce costs of feed production and improve poultry performance.

12.3. *Prevention of SP rotting losses*

308. Fresh SP tubers rot quickly, and rotting losses of up to 30 per cent of the harvested material is not uncommon with certain varieties. An important food and feed management consideration built into the project concept of chipping/shredding/gritting and then sun-drying SP is that these huge losses will also be prevented in addition to rendering the material suitable for use in poultry rations. The tuber and root storage feeding trial (paragraph) showed that there were no significant losses in the nutritive value of SP when gritted, sun-dried and stored for 6 months.

12.4. *Improving local agroprocessing and environmental problems*

309. The project rations were designed to maximise the use of local small-scale agroprocessing by-products and wastes. Traditional rural agroprocessing have come under stiff competition in recent decades from large-scale industrial processing, which because of economies of scale and new technology are efficient and can produce the primary product such as cooking oil cheaply. These industries are also able to realise high prices for their by-products because of the larger quantities generated at a single location on a regular basis. Adding value to oilseed by-products such as PPS and WPK by including it in the poultry rations will improve the financial viability of traditional processing. In the case of PPS, it also solves a major local environmental pollution proble, Similarly, the use of locally produced blood meal and bone meal from material generated in rural slaughter houses assists the disposal of these materials in a manner that minimises environmental pollution and improves the incomes of low income groups.

12.5. *Feed composition chart for project field site*

310. The development of a feed composition chart (Appendix 16.6) was deemed to be a necessary part of developing poultry rations. However, will have use in the western highlands of Cameroon and elsewhere with similar feed resources in assisting researchers to conduct other types of poultry ration developmental studies. If dissemination activities are undertaken to make the chart widely available and the method of using the chart is also shown through short courses in least-cost poultry ration formulation techniques, it will be of immense use to extension agents who would be able to train farmers in appropriate use of local feed resources.

12.6. *Institution building*

311. The project finances provided much needed appliances that will prove invaluable for other projects that may be undertaken at MRS in the future. The equipment purchased included numerous equipment relating to the poultry feeding facilities (troughs, brooding guards, etc). Funds were also used to rearrange the interior of the poultry houses so that these will assist in better design of any future studies involving feeding trials that are conducted. The TRS food processor sent from the UK will also assist in conducting experimental studies with many other local vegetables, including tubers and roots.

312. Above all, the benefits of the Optimix feed formulati on software package installed on MRS computer hardware represents the most useful component of institutional building. Since this was the first time that many staff had used such a package, it of this project. By demonstrating the use of this software package, the project manager provided training to MRS staff on the rationale of least-cost feed formulation. The training involved assessment of 'real life' examples of rations (for example, those shown in Tables 18, 19, 27-35, Appendix 16.7, Tables 1-6).

313. IRZV research team gained a great deal of experience during the project not only on poultry feeding and nutrition, but significantly on the intricacies of conducting adaptive research that is designed to increase the incomes of resource-poor farmers. This required an developing an awareness of the strengths and weakness of the target beneficiaries, and conducting interactive discussions with participating farmers. The project adopted a novel approach in poultry development with the focus on feed resource development through a mix of strategic and adaptive research by conducting feeding trials in controlled environment conditions, in on-station conditions and under farmer conditions in an iterative manner. IRZV researchers are now well-placed to take such project work forward after the completion of the project.

314. Effective transfer of knowledge in this area can only take place through adaptive research projects of the type implemented. The Director of IRZV has said that perhaps the greatest benefit of this project has been the transfer of knowledge from NRI to MRS. He writes further (letter dated 15 November 1996): 'it is very rewarding to realise that your exploratory visit some three years ago and subsequent discussions and understandings that followed have ended in this FTR (ie FTR for F0060) that bears with it a lot of hope for the small holder poultry farmer in Cameroon and why not, elsewhere. Yes, a lot of hope indeed given the prevailing situation characterised by extremely high competition for cereals for direct human consumption to the detriment of animal feeding. Ironically, the very population that *deprives* poultry of feed, needs affordable animal protein for its well being and an accessible source of income for alleviating poverty. This project, though disguised in its modesty has broken very fertile grounds in Cameroon that disposes of all ingredients of success for the development of peasant poultry production should the cereal-based feeding system find in it a viable substitute.

315. Thus, the project has opened a new dimension for the way forward on the optimisation of available feed resources in Cameroon. It helps to the people to help themselves to make most of their own natural resources. It is expected that in the future the researchers involved will disseminate the technical findings in journals, workshops and other scientific meetings, and promote the approach adopted in a project which has been a modest success.

13. CONTRIBUTION OF OUTPUTS TO DEVELOPMENT

13.1. *Poverty alleviation and nutrition of the poorer sector*

316. The outputs of the project contributes to poverty alleviation among the poorer sectors of the population by providing them with cheaper and more affordable poultry rations that reduce their dependence on commercial feeds. More poorer people will take up poultry rearing as an income generating activity since the rations designed are only suitable for this group. If the rations are adopted on a large scale it will also make it easier for poor people to consume more cereals the price of which will be reduced as a consequence of its replacement by SP and CAS. The price of poultry meat and eggs will also be reduced making it accessible to lower income groups to improve their nutrition and health.

13.2. *Livestock production*

317. The World Bank has set a goal of 4 per cent annual increase in food production in SSA to feed its growing population, improve nutrition, and eliminate food imports into the region. The LPP recognises the same targets for the supply of anuimal products. Thus, a priority area is to conduct research and technology transfer in ways of increasing the production of poultry products and improving the productivity of the poultry sector. The present project and other author's field experiences in SSA revealed that small-scale poultry production can play an important role in intensifying mixed farming systems, through the timely generation of cash for farmers, the optimal use of local feed resources, and the production of excreta which serves as (a) a high nutritional value dry season feed for ruminant livestock to supplement the otherwise low-nutritive value stovers and grasses that are available; (b) a fertiliser for crop cultivation or for horticulture. The main difficulty in assisting the small-scale sector is correctly assess their resources, constraints and opportunities and then to conduct the nutritional research that will lead to economically and environmentally sustainable mixed species livestock production system that are in harmony with a region's farming systems. The focus must be on reducing the dependence of the resource-poor poultry producer on commercial feeds by maximising the use of feed resources at his or her disposal. The development of socio-economically acceptable rations requires a combination of strategic and adaptive research on rural feed resources that vary according to agro-climatic zones, local agro-processing activities, and the varieties of crop plants cultivated.

318. The project has also demonstrated that it is possible to impr ove livestock production and productivity to generate income by resource-poor farmers and other low income groups in an environmentally conscious manner such as minimising the use of fossil fuel in poultry feed processing and preventing pollution (as with palm pit sediment). The approach, based as it was on optimising the use of local feed resources including traditional rural agroprocessing by-products and wastes, itself makes a contribution to development as a way forward for livestock developmental projects.

13.3. *Replacement of cereal component of livestock feeds*

319. Reducing the use of cereals in livestock feeds is an important aspect of food resource management in the future, due to fact that yield increases per hectare are no longer keeping pace with rising populations and unexploited cropland is also limited. Maize prices have continued to increase in the US (the world's largest exporter) with the result that the use of maize in the poultry industry will be limited (Hooge, 1996). There is, therefore, increasing pressure worldwide to use alternative raw materials recently identified as being one of 5 priority areas for research in poultry production (Williams, 1997).

320. The competition for maize between human food and livestock feed sectors is a major developmental issue globally, but for developing countries in particular because these are generally dependent on imports of this cereal. This project has developed cereal-free broiler chicken rations that have been demonstrated to be more profitable than the normally used maize-based rations in intensive poultry production system. If the rations are adopted on a large scale it will reduce the competition and make it easier for poor people to consume cereals. Similar concepts can be tried elsewhere, if not to completely eliminate the use of cereals to substantially reduce it.

13.4. *Feed technology: gritting and sundrying tubers and roots*

321. The contribution of the technology of gritting, sundrying and storing SP as animal feed was seen in the project area in late 1996-1997, when the price of maize rose so high that the local Ministry of Agriculture approached IRZV for advise on cereal-free rations feeds for all major classes

of livestock, including poultry, pigs, dairy cow and rabbits. The PRTC requested the second prototype gritting machine from IRZV, which was given after NRI was contacted for permission. PRTC produced mixed and sold animal feeds which livestock producers from up to 30 km away came to purchase.

322. The development of SP and CAS as poultry feeds using solar energy has cost and environmental adavantages over the alternative of using oven-dried maize. It should therefore be mentioned that a different situation exists in countries without a significant dry season (paragraphs). In Yaounde, ie South-East, the weather is very humid and hot compared with the highlands of Bamenda and it takes a day or two to acclimatise; this is necessary especially after arriving from 0 ^{o}C in Britain! In the highlands mountainous mid to high altitude agroclimatic zone, it is quite hot by mid-morning but dry heat, so no sweating takes place; the nights are cooler and air-conditioner is not necessary. As regards the project to convert root and tubers to poultry feeds, the Bamenda region is ideal from the climate point of view to add to the socio-economic and agronomic considerations. The preliminary trials showed that in January-February, the sphaghetti shaped sweet potato and cassave chips dried in one day if sparsely spread, the economic optimum. The technology will be more difficult to make it to work if it is conducted in the humid south-east, where even clothes take longer to dry compared with the Bamenda region (refer to deleterious effects of slow drying on nutritive value of sweet potato). This will apply to countries like Peru, that are also humid all year round.

13.5. *Tubers and roots for large-scale animal feed production*

323. For commercial feed millers in economically well-developed countries the development sweet potato-based poultry feed could also consider the use of commercial enzymes and extrusion technology, two commonly used techniques for improving the nutritive value of high starch commodities. Unfortunately, however, feed compounders and institutions in developing countries are generally unable to conduct this type of research because of lack of suitable facilities and resources. In the production systems enzyme application to feed ingredients, such as galactosidases, xylanase, amylnase, protease, B-glucanase may be useful in cost effecting enhancing nutritional value

13.6. *Research methodology for livestock systems adaptive research*

324. During the course of implementation, a novel research methodology was also established for the development of poultry rations for small-scale producers through an interative process of strategic and adaptive research by conducting feeding trials in controlled environment conditions to establish feed potential; on-station feeding trials under researcher control for pre-testing of tentative rations, and finally, on-farm trials under farmer control to test the applicability of the rations developed. This approach could be applied in other concepts such as in agroforestry/livestock where tree leaves are considered as poultry feeds.

325. It should, therefore, aim to keep as many of the technical aspects as simple as possible drying within a day, starter-finisher). One of the considerations of the technology development is not to stick to the current stage of sun-dried cassava chips, otherwise the rich farmers will purchase it and the poor poultry farmers will be where they are, marginalised. Whilst, the purchase of large quantities of tubers and roots by large commercial poultry farmers will naturally benefit the crop farmers, it may not be sufficient to assist the small-scale poultry farmers working from within a mixed farming systems. John Ngwa said that the rich farmers will once again monopolise the process and the poor poultry farmer will remain in the same position, only worse if the cost of eggs in the market falls as a consequence of the new technology introduced.

326. Another problem is the variability in the composition of complementary feeds. CSC varied in crude protein content between 33 and 42 % lysine from 1.33-1.97 percent and free gossypol from

715-1350 mg/kg. It is within such 'unconventional' nature of feeds that on-farm feeding systems need to be developed.

327. Thus, the project technology must be developed specifically with these farmers in mind. To achieve this, it must be such that the it would be too much trouble for the rich poultry farmers to be interested in, or too risky for them given their high capital intensive operations of even imported feedstuffs and other elements. Risk: rich farmers may not be able to see egg production fall from 94 to 70 % if much money is tied in whereas the poor farmers with low input-output systems, and where poultry is only one of several enterprises they are involved in, included off-farm employment, they can take sudden falls, and in fact do as they look for cheaper feeds such as infested maize and palm kernel cake from traditional oil extraction methods. They have the time to go and collect small quantities of these from the villages, which the rich farmer will not be able to do. Palm pit sediment is another example. So the solution is to develop feeds simulataneously to blend some of these other cheap or discarded materials into root-crops based poultry diets specifically for these farmers, and which will not be of interest to the large commercial farmer: a separate small-scale poultry feed sector may be set up.CLM is easily dried and has potential interms of nutritive value and pigmentation for yolk colouring. It was therefore used in the rations, whilst SPLM was not so useful and discarded. It would serve as a better feed for rabbits and goats in the regions farming systems.

328. There is also the final stage adaptive research required when the figures of quantities of ingredients in rations need to be rounded up and converted to measures that resource-poor producedrs possess, such as buckets and containers (see paragraph 298).

329. Thus, the technology being developed must start by considering the resources, opportunities, constraints, and problems of the poor poultry farmer in relation to the demand for their products; these farmers need to be visited and discussed with. The ideal will be to work and develop technology that does not change their current way of lives, either for the crop farmer, the small-scale agroprocessor or the poultry farmer. However, if a technical optimum is found, it should be discussed with them. But far better to see the various ways in which the job is being done and see which is best for chickens then change the others. Same with poultry farmer: improve existing systems, not impose new ones. This way we optimise the use of their resources in relation to their goals and socio-cultural norms - sustainable management of their natural resources. This project ties up sweet potato, palm cultivation and chickens in this manner.

13.7. *Need for development of appropriate crop varieties identified*

330. Inadequate attention to food and feed utilisation aspects of the crop developmental activities of the IARC centres have frequently resulted in new high yeilding varieties of crops being introduced that have proven inappropriate in specific socio-economic environments. It was apparent that consideration of utilisation aspects was negligible in the breeding strategies that have been hitherto adopted for for sweet potato. In none of the countries visited by the author was there a discernible breeding strategy employed apart from the agronomic ones of high yields. It is common for new varieties to be first introduced and to conduct research on how to use the product on varieties that have passed the 'agronomic' test. This has led to varieties that did not meet consumer demand. This strategy is forced on the CGIAR's because they lack facilities for evaluating utilisation aspects, such as the nutritive value of feeds for human and livestock.

331. The case for integrated concepts for agricultural development, in particular for the 'push-pull approach' or 'production to consumption systems approach' (PCSA), is now widely recognised as the most appropriate basis for agricultural development. This project addresses a constraint in the PCSA chain as it affects some countries of sub-Saharan Africa, namely the underutilisation of root crops at the same time that cereals required for humans are imported for incorporation into poultry feeds as the major energy source. The project has demonstrated that greater attention needs to be paid to utilisation characteristics of tuber and root crops in breeding programmes.

332. The project has also highlighted the need for crop and livestock research to be developed in parallel. There is a need for greater emphasis on the utilisation characteristics of new cultivars for use as animal feeds before promoting new varieties of tubers and roots in developing countries.

333. Agronomic details are required on TIB1, TIB2, 1112, CIP No 193002.1 (AVRDC 5.018) and 490141.1 (RURB 15.004). Details should include foliage:tuber yield. the consideration is that for the purposes of this particular research project, it is OK to use the existing varieties, but if more digestible, easier to process and dry varieties were available that were not particularly prone to weevil (find out whether there is a correlation between weevil damage and trypsin inhibitors), given that storage losses will be brought to very low levels with this technology, it would be more appropriate to chose it. A separate basic research collaboration with CIP needs to be set up to monitor 6 kg sun-dried grated sweet potatoes in Peru to be sent to NRI for assessment as poultry feeds.

334. The adaptive research they then be modified by, for example, having the particular clones (AVRDC 5-018, CHGU 12-001 and CHGU 1-003) grown in Cameroon, Kenya or Uganda on a large scale. There is a need to select cultivars with thin or more digestible peels, a high dry matter content, and high dry matter digestibility when sun-dried, and texture that promotes high feed intakes by chicks.

13.8. *Need for esearch collaboration between livestock and crop research centres identified*

345. The CGIAR crop centres such as CIP, IITA and International Crop Research For the Semi-arid Tropics do not have the mandate to conduct livestock trials. It follows from the above discussion that this project has highlighted the need for research institutes involved in animal production such as NRI and IRZV to engage in on-going collaborative research with crop research insitutes to assist in the selection of varieties of crops (SP and CAS in the context of the present project) that are better suited to development as poultry feeds. A Chart of the type of research data on utilisation characteristics required is shown in Appendix 16.8. Such data requires consideration along with agronomic data before new varieties are introduced in developing countries.

14. PROJECT FOLLOW-UP ACTIVITIES

336. Limited dissemination has thus far been undertaken since the project is incomplete and lack of funds. Additionally, it is necessary to consider the next stage in the continuum from research to practical application in view of the progress made in the form of an agricultural project in the western highlands.

14.1. *Dissemination of project findings*

337. The following dissemination activities have been planned.

14.1.1. *Publications and Reports*

338. A scientific paper describing the processing and nutritional characteristics of two varieties of SP for poultry has been published (Panigrahi *et al*, 1996a), and a review paper on the use of cassava root for poultry production was presented at the *International Symposium on Tropical Tuber Crops*, 6-9 November 1993. Indian Society for Root Crops, Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapurum, India by the author of this report (Panigrahi, 1996). Sufficient research data has been collected from the feed developmental research undertaken in this project to write another 4-5 scientific papers.

14.1.2. *Regional Workshop*

339. Although Cameroon was not on the priority list of countries for the Livestock Production Programme, sub-component project F0060 was approved by ODA because of its global significance. It would, therefore, be appropriate to organise regional workshop to discuss the approach that has been adopted in the present project and to present its findings so as to encourage similar work to be undertaken by NARS in other West African countries.

14.1.3. *Design of leaflets and posters*

340. A poster for promoting the use of SP in poultry feeds has been developed for display at IRZV offices and those of extension agencies in Cameroon (Poster 1). It would be appropriate to design a similar one for cassava given that the potential for using cassava to replace maize in poultry diets has now been proven to be greater than that of sweet potato. The leaflet has been sent to CIP in Peru for wider dissemination in its Headquarters and through its regional offices throughout the developing world.

14.1.4. *Assisting animal feed millers*

341. A stakeholder system of integration comprising the processing of roots and tubers into grits, and their marketing to poultry producers or small-scale animal feed manufacturers will be required to promote the ration technology developed in this project. A system of production and utilisation is essential for large-scale adoption of cereal-free poultry rations. The private sector has an important role to play in promoting the concept of replacing cereals with maize. A distinction however should be made between three types of beneficiaries in terms of the ration characteristics that would be applicable for each. Large-scale producers are considerably more restricted in the rations and production methods they use than small-scale millers who in turn are more restricted than resource-poor farmers mixing their own feeds. Thus, each category requires a different type of assistance in agricultural projects. One of the on-farm project participants who owns a small animal feed shop was given rations that utilised materials such as brewery dried grains which may only be available intermittently (Appendix 16.8). Similarly, large-scale animal feed compounders need to be assisted with appropriate technology to convert tubers and roots to suit their production systems.

14.1.5. *Assisting NGOs*

342. PRTC and other local NGOs and Womens groups such as CAMWIDCO will be included in a agricultural project which will follow the research phase of the present project.

14.2. *Agricultural project*

343. There is a need to promote development in this area and take the concept from research to practical application. To maximise benefits of the project-developed technologies to the poorest farmers and other low income groups an approach is needed that brings together farmer groups and local NGOs in an agricultural project as four stakeholders: those cultivating tubers and roots, those processing the tubers and roots, those engaged in animal feed production, and those rearing chickens. Following the development of a suitable manual gritting machine, an agricultural project proposal for submission to aid agencies will be developed by NRI and IRZV in collaboration with CIP, and other local NGOs and government extension agencies working with poor farmers.

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