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2 List of Acronyms used in report

AME	Apparent metabolisable energy
C	Cassava
CAS50H	50% cassava mixed with high energy concentrate
CLTC	Christian Leaders Training College
CP	Crude Protein
DOC	Day Old Chickens
DMD	Dry Matter Digestibility
EHP	Eastern Highlands Province
FCR	Food Conversion Ratio
HEC	High energy concentrate
HELC + SP	High energy layer concentrate with sweet potato
K	Kina
KGA	Kastom Gaden Association
LFM	Lae Feed Mills
LDS	Lutheran Development Service
LEC	Low energy concentrate
LELC + C	Low energy concentrate with cassava
NARI	National Agricultural Research Institute
NDAL	National Department of Agriculture and Livestock
NGO	Non Government Organisation
NGTB	New Guinea Tablebirds
Ok Tedi	Ok Tedi Development Foundation
OTML	Ok Tedi Mining Limited
PARE	Participatory Agriculture Research and Extension
PIRSA	Primary Industry and Resources South Australia
PPPI	Pig and Poultry Production Institute
SA	Salvation Army
SARDI	South Australian Research and Development Institute
SI	Solomon Islands
SP50L	50% sweet potato mixed with low energy concentrate
UniTech	University of Technology
WPSA	World's Poultry Science Association
YD	Yangpela Didiman

3 Executive summary

Improving the profitability of village broiler farming through the use of locally available feedstuffs has been a high priority in the PNG livestock sector for over 15 years. Lowland provinces close to the commercial feed mills account for 60% of broiler production with 40% in highland provinces. The village broiler Industry is valued at $67m. The viability of village broiler farms in both geographical regions has been continually threatened by the rising costs of imported ingredients used in commercial feeds. An earlier ACIAR project (LPS/2001/077) developed a feeding system whereby PNG protein meals (plus minerals and vitamins) were used to produce a concentrate that could be mixed with 50-80% of local ingredients and fed to broilers. The feeding method resulted in good bird growth.

This project focused on delivery of the feeding system to village farmers through the participation of NGO's which included the Christian Leader Training College in the highlands, Lutheran Development Service in the lowlands and OK Tedi Development Foundation in the Western Province. The NGO's either renovated or built poultry housing facilities suitable for conducting regional specific broiler feeding demonstrations for village farmers.

Initially the Apparent Metabolisable Energy (AME) was evaluated for concentrate diets that had low energy (AME 9.6 Mj/kg, CP 40%), medium energy (AME 10.5 Mj/l/kg, CP 43.5%) and high energy (AME 11.7 Mj/kg, CP 41%) at the NARI broiler feed evaluation unit in Lae. The diets were further evaluated by NARI in grow-out trials with the most suitable found to be; 1) 50% sweet potato + 50% low energy concentrate; 2) 70% sweet potato + 30% low energy concentrate; and 3) 50% cassava + 50% high energy concentrate. These selected diets were then tested in regional broiler grow-out trials in the highlands at CLTC's Banz Campus, in the lowlands at LDS's Mahalang Campus and at Ok Tedi Agricultural Resource Centre at Tabubil in the remote Western Province.

The demonstration feeding trials conducted at CLTC indicated that the diet with the greatest potential in the Western Highlands Province was 50% of the low energy concentrate supplemented with 50% of sweet potato. The demonstration activities conducted at LDS showed that the diet best suited for lowland chicken meat production was 50% high energy concentrate supplemented with 50% cassava. At Ok Tedi broilers grew equally well when fed poultry concentrate supplemented with 50% cassava or 50% sweet potato.

As a result of the promising results obtained in the regional trials each NGO selected village farmers to run trials to compare the concentrate feeding system with a standard broiler feed. Four regional village broiler feeding trials were run which involved feeding sweet potato with a low energy poultry concentrate to broilers in the highlands and cassava with a high energy concentrate in the lowlands including demonstration activities in the Western Province. The trials were conducted at Malahang, Finschafen and Madang in the lowlands; in the Banz and Kainantu districts in the highlands and at Kiunga, Star Mountains and Tabubil in the Western Province. Broiler performance (particularly the sweet potato diet) compared favourably with commercial feed in all the village farm trials. Birds reached market weight (>2 kg) soon after 5 weeks of age.

Most of the village farmers involved with the trials indicated an interest to continue using the concentrate mix. There was also strong interest expressed by other broiler farmers not involved in the trials. Some farmers wanted more information about other alternative feed resources to use with the concentrate especially in the coastal regions. The feeding system is appropriate and boosts village broiler income by reducing the cost of feeding broilers. Farmers prefer the flavour of meat from birds fed with the concentrate and sweet potato or cassava mix.

To determine if the feeding strategy will be adopted by village farmers an economic assessment was made to determine the cost of locally milled broiler concentrate compared to the price of the commercially available alternative at several key sites in PNG. Spreadsheets were developed on the cost of producing concentrate feed from mini-mills and profit of village broiler grow-out operations to assist with the economic assessment.

At approximately K800/t, the mini-mill concentrate is more than competitive with commercial full rations (K2000/t) and a commercial concentrate (K2400/t). The mini-mill concentrate price was based on cost of local ingredients and mini-mill equipment, as well as setup and running costs. Fishmeal, copra meal, mill run and premix are the ingredients intended to be used to produce the concentrate. The technology will achieve village enterprise broiler production market penetration if the local based feed ingredient price including labour is less than 70 percent of the import based feed ingredient price including labour. The calculations indicate that the mini-mill concentrate plus local carbohydrate including labour represents 56% of the full commercial feed plus labour costs, and the commercial concentrate concept plus local carbohydrate and labour is 69% of the full costs. Hence both “local” feed systems could achieve market penetration, but especially the mini-mill concentrate system. The local carbohydrate source was either sweet potato or cassava at K0.7-1.0/kg in the lowlands and highlands.

A benefit-cost analysis of the economic impact of the R, D & E program to improve the profitability of village broiler production in PNG was carried out. Other options include a commercial high protein concentrate feed plus local carbohydrate source and a dilution strategy of half normal commercial feed plus local carbohydrate source. The estimate of the research costs was 3.3 M kina. On the core assumption of 35 percent market penetration of these new technologies, the analysis showed an internal rate of return to the program of 25% p.a. and a net present value of 45.6 M kina. The benefits were attributed to a producer surplus of 16.3 M kina and a consumer surplus of 32.7 M kina.

Strategies to publicise the benefits of the broiler feeding system in PNG included field days, training and demonstration sessions run by NARI and other NGO partners and distribution of publications. NARI and partners used radio programs, newspaper articles and reports on the NARI website to disseminate the technology. Fact sheets of feed resources available in PNG for broiler feeding were developed for College, University and NGO curriculums. A video on how to use the feeding systems was also produced by NARI as part of the dissemination activity.

It was considered timely to extend the project for 18 months from July 1, 2011 to demonstrate if the feeding system developed for broilers based on using a concentrate mixed with sweet potato or cassava could be adapted for use in indigenous poultry, imported hybrid layers and Australorps crosses to reduce feed costs. The demand for eggs is increasing in PNG as the mining industry and associated support industries expand.

Two concentrate rations for laying hens were formulated; one that could be fed with sweet potato and the other with cassava. The sweet potato diet (HELC+SP) had an apparent metabolisable energy (AME) of 11.8 Mj/kg and contained 40% of cooked sweet potato. The specifications of the concentrate diet when mixed with cooked sweet potato diet were; CP (17.2%), total fat (3.9%), fibre (7.5%), calcium (3.4%) and phosphorus (0.7%). The cassava (40% inclusion rate) diet (LELC+C) specifications were AME (10.9Mj/kg); CP (16.9%), total fat (3.8%); fibre (4.6%), calcium (3.3%) and phosphorus (1.0%).

To test these diets laying hen facilities at NARI were used. The performance of a commercial hybrid fed 3 diets; 1) commercial control layer diet, 2) HELC + SP diet and 3) LELC + C diet was compared to the performance of village chickens and an Australorp x commercial cross over the peak egg production period from 25-34 weeks. The village hens had the lowest production while the Australorp cross achieved consistently higher egg production compared to the commercial hybrid. This was due to the high levels of cannibalism and feather pecking in the commercial hybrid. The Australorp cross and village hens fed the SP and C based rations had lower mortality than the commercial hybrid indicating that genotype influences the incidence of cannibalism. There is a need to use beak trimming in PNG to control pecking problems in modern hybrids. Hens fed on LELC + C diet performed better than birds fed on the HELC + SP diet and the standard diet. The use of village chickens, locally bred hybrid crosses and commercial hybrids fed with sweet potato or cassava based diets was considered beneficial for further testing at NGO sites.

To evaluate the performance of birds on the SP and C based diets, trials with commercial hybrids and village chickens were conducted at NGO partner sites (CLTC in the highlands and LDS in the lowlands). At CLTC commercial hybrids were fed 3 treatments diets from 25-37 weeks of age; 1) commercial layer diet, 2) HELC + SP and 3) LELC + C while at the LDS site village chickens were fed the same treatment diets from 25-33 weeks of age.

The commercial hybrids at the CLTC site fed the SP and C based rations had lower feed intake relative to the control birds, they produced fewer eggs and had lower egg weight but feed conversion was superior.

At the LDS site, village hens fed on SP and C based rations had higher egg production compared to birds fed on the commercial ration but had poorer feed conversion. On the basis of cost it was determined that the most affective feeding option for layer type birds was the SP based diet. The commercial layer concentrate was the most costly.

Following on from the on-station and NGO feeding trials, on-farm trials were selected in the highlands and in the lowlands. In the lowlands, the Amale area in the Madang province was selected as one of the locations to evaluate the LELC + C diet compared to a commercial diet when fed to village hens. The trial ran 10 weeks. Birds fed the LELC+C diet performed better than the commercial diet when assessed on the basis of average egg weight and FCR. The farmers were very pleased with the performance of the birds fed the LELC+C diet. At the official closing of the trial, there was a high turn up mostly of women, youth and village elders who wished to get further involved. In the highlands on-farm trials both the Australorp crosses and commercial layers had similar peformance when fed HELC + SP.

The greatest potential for providing smallholder poultry farmers with cheaper feed is to encourage the manufacture of feed through regionally based mini mills. Economic models indicate that the cheapest feed can be provided by small scale commercial feed mills. However the model was based on indicative costs and income and there was a need to verify the model using data from a commercial enterprise. A component of the project extension was to evaluate the performance of one newly established commercial mini mill. The Domil Integrated Community Development Cooperative Society located in the Jiwaka Province in the highlands of PNG opened its model mini mill in April 2012. The products from the mill are cassava flour, cassava starch and broiler cassava finisher feed which is being sold to farmer members of the cooperative. The cassava based broiler feed is primarily based on the poultry broiler concentrate developed earlier in this project. The cooperative created a revolving scheme where registered members were able to obtain a loan to raise broilers. The broilers are grown out by farmers and sold back to the cooperative. The birds are processed and packed at the mill site and then sold in Mount Hagen. There was a 12% savings in feed costs at the Domil mill compared to using commercial feed.

4 Background

Improving the profitability of village broiler farming through the use of locally available feedstuffs has been identified by NARI as the highest priority initiative in the PNG livestock sector. This sector produces about 7M birds per year valued at A$67m using birds of high genetic potential fed with commercial feeds. The PNG Liquefied Natural Gas project and other mining projects have resulted in a greater demand for chicken meat and eggs. In particular there is an emerging market demand for indigenous chickens. Local communities and other ethnic groups prefer the texture and flavour of indigenous chickens and their eggs. Lowland provinces close to the feed mills account for 60% of poultry production, with 40% in highland provinces over the last 10 years.

Viability of poultry production in both regions has been threatened by rising costs of imported ingredients for the commercial feeds. This problem has been made much worse by the reduction in the value of the Kina and consequent increases in cost of all imports. As most feed ingredients are imported this has led to the approximate doubling of costs of broiler production. When transport problems are added (and these are also made worse by rising real cost of fuel), the smallholder broiler industry that relies on imported ingredients has been subjected to large increases in costs.

Food crops such as roots, tubers, lesser known plants (FAO, 2012) and agro-industrial by-products, such as copra meal, fishmeal and palm kernel meal, are available in PNG and have been shown to be suitable for use in broiler rations. However, the high cost of transport, storage difficulties and constraints in feed formulation make it difficult for the feed mills to use these feed resources in complete rations.

Commercial production of feed for the monogastric industry especially for the modern broiler chicken in developed countries is aimed at maximising the genetic potential of the birds by providing a feed that is energy and protein rich to meet the chicken's nutritional requirement at a particular age or stage of growth. Maximising poultry performance in developing countries is often difficult to achieve and emphasis needs to be placed on matching production with the available feed resources (Farrell, 2005). Matching production of the hybrid broiler chicken with locally available feed ingredients in tropical environments is now a major factor determining alternative feeding strategies in PNG and other South Pacific Island countries.

Dried sweet potato has been fed successfully in rations for broilers, layers and pigs at a level of up to 35% (Fashina-Bombata and Fanimo, 1994). Fifteen % dried cassava leaf meal can be included in a broiler diet while Akinfala et al. (2002) reported that sun-dried whole cassava plant meal can be included up to 12.5% to 25% in a broiler starter diet. Ofuya and Obilor (1993) found that fermented cassava peel can be used for young poults. Supplementation with methionine for a diet containing 20% cassava leaf meal improved the gain of birds (Ravindran et al. 1996). Sonaiya (2013) reported that 20 to 45% cassava peel meal can be fed to chickens. However, Akinfala et al. (2002) found that the growth rates and feed conversion were impaired when birds were fed with 12.5% cassava meal in the diet.

Project LPS/2001/077 developed an alternative strategy whereby PNG fishmeal and copra meal (plus minerals and vitamins) were used to produce a concentrate that can be supplemented with 50-80% of local ingredients (eg. sweet potato) to make up the whole ration. This project expanded and tested a range of concentrates mixed with local feeds on-station and on-farm, and examined two strategies to produce concentrate feeds: first through the on-going relationship with Lae Feed Mills and New Guinea Table Birds, and further through an alliance with the regional fish feed manufacturing and distribution centres associated with project FIS/2001/083: Inland aquaculture in PNG: improving fingerling supply & fish nutrition for smallholder farms. The establishment of commercially focussed mini-mills in PNG to serve the poultry, pig and fish sectors offers significant potential.

The ACIAR project LPS/2001/077 laid a solid foundation to assist in the development of the smallholder poultry sector in PNG, enabling this project to place a strong focus on delivery of feeding strategies to village farmers through the leading participation of NGO's and the conduct of on-farm evaluation trials.

5 Objectives

The aims of this project are to improve the profitability of smallholder broiler production in PNG by at least 25% and to increase smallholder broiler production by 5% per annum through greater use of lower-cost locally available feed resources.

Objective 1: To develop on-station a range of best-bet feeding options for broiler production and profitability

Objective 2: To evaluate broiler production and profitability on-farm of various feeding options that incorporate local feeds.

Objective 3: To promote the wide-spread adoption of alternative feeding options for broilers (and layers) that will improve profitability.

Project Extension-evaluate feeding options for laying hens

Objective 1: To develop a commercial mini mill enterprise.

Objective 2: To develop on-station a range of best-bet feeding options for indigenous poultry, imported hybrid layers and Australorps.

Objective 3: To evaluate layer production and profitability on-farm of various feeding options that incorporate local feeds.

6 Methodology

6.1 Objective 1: To develop on-station a range of best-bet feeding options for broiler production and profitability

6.1.1 Develop low cost concentrate diets to feed with sweet potato or cassava

Formulation of low cost concentrate diets **for broilers** were developed by SARDI scientists in consultation with Lae Feed Mills (Goodman Fielder International), New Guinea Table Birds and nutrition consultants. A low energy (CP 40% and 9.8 Mj/kg), medium energy (CP 43.5% and 10.4 Mj/kg) and high energy (CP 41.0 and 11.8 Mj/kg) broiler concentrate diets were formulated so that they could be fed with 50-70% of local ingredients (e.g. sweet potato and cassava) to make up the whole ration.

The composition and calculated nutrient specifications of the high, medium and low energy diets identified as HEC, MEC and LEC were as follows:

HEC (High energy concentrate) (11.8Mj/kg); Composition (g/kg), sorghum 118; soya 485.9; meat & bone meal 286; tallow 65; L-lysine 12.5; DL-methionine 11.8; L-threonine 1.3; salt 5; mycocurb 1; choline cloride 4.5; boiler premix 9.

Specification (g/kg); Protein (419.75), Arg (28.59), Isoleuc (15.95), Lys (32.89), Meth (17.41), M+C (23.25), Threo (16.58), Fibre (23.62), Ca (27.56), P tot (16.73), Av P (9.4), Na (3.58), K (10.48), Cl (6.08).

MEC (Medium energy concentrate) (10.4Mj/kg): Composition (g/kg); Wheat 83; meat meal 525; mill run 140; choline chloride 6; Rhodimet 17.3; Lysine 16.6; L threonine 2.2; broiler premix 7.5; sorbasafe 1.

Specification (g/kg); Protein (435.7), Fat (48.2); Arg (28.19), Isoleu (14.91), Leuc (28.30); Lys (36.3), Av Lys (33.3); Tryp (4.1); Arg (28.49); Meth (19.4), M+C (24.8), Threo (16.4), Linol (5.0); Salt (9.70); Fibre (39.7), Ca (36.4), P tot (20.18), Av P (15.0), Na (3.7), K (10.5), Cl (6.43).

LEC (Low energy concentrate) (9.8Mj/kg); Composition (g/kg); mill run 246; soya 389.45; meat & bone meal 309; tallow 8; L-lysine 13.8; DL-methionine 12.4; L-threonine 1.7; salt 5; mycocurb 1; choline chloride 4.5; ronozyme phytase 0.15; broiler premix 9.

Specification (g/kg); Protein (417.87), Arg (28.19), Isoleu (14.91), Lys (33.01), Meth (18.01), M+C (24.03), Threo (16.45), Fibre (38.47), Ca (30.29), P tot (20.18), Av P (11.44), Na (3.7), K (10.5), Cl (6.43).

6.1.2 Train operators of regional mini-mills in formulation and feed mixing

A feed manufacturing workshop was conducted in Aiyura in the Eastern Highlands Province of PNG from 6-8 December 2006. Approximately 40 participants attended the workshop including small scale farm-holders, provincial and government representatives as well as students. The majority of participants were actively involved in either the production of fish or poultry.

Each participant was presented with a workshop folder containing introductory material and printed versions of all power-point presentations from presenters. Key topics covered during the workshop included principles of aquaculture and poultry nutrition, potential feed ingredients, introduction to diet formulation, principles of feed manufacture, feed management and storage and feeding strategies. In addition each participant was given a CD containing PDF copies of all presentations. Participants were also provided with a hard-copy of an ACIAR publication titled "Preparing Farm Made Fish Feed in Fiji & PNG" as well as literature on the nutritional requirements of poultry. Other resource material included an extensive list of potential feed ingredients for use in fish and poultry diets and a simple pro-forma for conducting small scale feeding experiments. In total, these resources provided each participant with an extensive amount of introductory level material on fish and poultry nutrition.

A further mini-mill training course was run in conjunction with Project Support Services. The emphasis was placed on training participants of the project on how to operate small-scale feed mill equipment. This activity was undertaken in conjunction with the project inception meeting. Project Support Services Ltd with support from SARDI and NARI staff conducted training for PNG and Tongan staff in Lae.

6.1.3 Feeding options identified for highlands and lowlands produced in commercial feed mills

The best feeding options were determined by running experiments using the group cage AME bioassay facilities in Lae, PNG established under SARDI's supervision.

Mixed-sex, commercial broiler chickens housed in a naturally ventilated shed were reared from 0 - 21d on litter under infra-red heat lamps. A commercial starter diet was provided until chickens were placed on experimental diets. On day 21, chickens in the weight range 750 - 950g were allocated to AME cages by placing four chickens in each cage (W 60cm, H 38cm and L 45cm). Temperature was maintained in the range 20 - 25°C during the 7d test period.

All cages had individual feed troughs and nipple drinkers. Each cage was shielded to prevent cross-contamination of excreta. A control diet with a stable AME value was run with each batch of experimental diets. Each experimental diet and the control diet were replicated four times (total of 16 chickens). Chickens were given 3d to adapt to cages and experimental diets.

The AME of the following diets were determined; Lae Feed Mill broiler starter and finisher diet, HEC + 70% cassava, HEC + 70% sweet potato, MEC + 70% cassava, MEC + 70% sweet potato, LEC + 50% cassava and LEC + 70% sweet potato.

After the 3d adaptation period the excreta trays are cleaned thoroughly and records of bird feed consumption obtained. The excreta were collected daily for 4d. Feed and feathers were removed from excreta. The excreta were dried on aluminium trays in a fan-forced oven at 90°C overnight. All dried excreta from the same pen were pooled. Total weight of excreta from each pen was recorded and ground finely. Representative feed samples were placed in screw-capped containers, and stored in a fridge at 4-6°C. The gross energy (GE) of excreta and feed samples was determined with an adiabatic bomb calorimeter (after standardizing with benzoic acid).

The AME of the experimental diets were determined as follows:-

AME of diet = [(GEdiet x g feed consumed) - (GE excreta x g dry excreta)] / g feed consumed. AME of each feed was calculated.

Feed intake (g/bird/day) = (feed eaten adaptation + feed eaten collection) / (no. birds × 7 days).

Live weight gain (g/bird) = (live weight at end – live weight at start) / no. birds.

Feed conversion = total feed eaten (g) / no. birds / live weight gain.

Excreta moisture (%) =

(Wet excreta weight – dry excreta weight) / (wet excreta weight - excreta container weight) × 100.

AME is measured as (MJ/kg DM) of diet.

Dry matter (DM) digestibility = (g feed retained/g feed eaten)

6.1.4 Establish on-station grow-out facilities in the lowlands at LDS, at CLTC in the highlands and at OK Tedi in the Western Province, including protocols and training for the conduct of trials

Design of the facility

LDS staff provided a photograph of an existing deep litter poultry shed. SARDI staff designed the layout of the shed suited for conducting replicated broiler feeding trials. The details of the design are shown in appendix 1.

Likewise CLTC provided details of an existing shed. The internal structure of the shed was designed to allow a centre pathway with 16 individual pens (suitable for housing up to 50 meat birds). The details of the design are also shown in appendix 1.

In the case of OK Tedi no existing poultry facility was suitable for renovation. Therefore a new shed was designed taking into account the local climate. In particular the shed design included building the shed above ground on stilts to prevent flooding of the facility. The design included a centre corridor with 8 pens suitable for conducting trials with up to 400 meat or laying birds (see appendix 1).

Training of staff

Phil Glatz visited each of the NGO sites to ensure the facilities at LDS, CLTC and OK Tedi were constructed according to the design provided. In addition protocols for running broiler trials were provided to NARI and NGO staff which included shed fit out, bird placement, trial procedures, data collection and shed clean up. During the running of the trials NARI staff provided day to day supervision of the NGO staff involved in the trial.

Scientific protocols

Phil Glatz advised NARI and NGO staff on quality assurance protocols for demonstration trials. Staff at each site were given instruction on record keeping, other documentation and analysis of the trial data.

Training to run a village poultry unit

Derek Schultz from SARDI conducted training at CLTC, LDS and with the Salvation Army to assist staff to develop protocols for running demonstration trials on village farms.

6.1.5 Undertake region-specific grow-out trials to develop local knowledge and refine best-bet options for testing on-farm

The grow out experiments were undertaken at research demonstration facilities established at CLTC, LDS and OK Tedi to determine diets suitable for testing in village trials in the highlands, lowlands and the remote Western Province.

The regional grow-out trials consisted of 4 treatments (the 3 best-bet experimental diets; SP50L, CAS50H, SP70L and the NGTB broiler finisher diet). At all sites eight experimental pens were used with two replicates of each of these diets. There were a total of 20 birds with equal numbers of females and males in each experimental unit. The experimental design used for all three sites was a randomised block design. From day 1 to day 21, the broiler chickens were fed with the NGTB starter crumble feed. The experimental diets were fed from day 21-42.

6.1.6 Develop a commercial mini mill enterprise (project extension)

A component of the project extension was to monitor the development of a commercial mini mill. The Domil Integrated Community Development Cooperative Society located in the Jiwaka Province in the highlands of PNG opened its model mini mill in April 2012.

NARI researchers trained Domil staff how to manufacture the concentrate feed using the mill equipment. The cost and income was assessed to determine the profit of the mill enterprise. Before the training of Domil staff NARI purchased a research mini mill which included a hammer mill, grater, flake mill, feed mixer, boiler, pelleter, solar drier and ancillary equipment such as knives, axes, buckets, trays, canvas, scrapers, mortar and pestle, weighing scales and bags. A NARI concentrate diet was formulated and comprised 26.8% fish meal, 32.2% soybean meal, 15.8% cassava leaves, 14.7% maize, 3% copra meal, 2.3% kikuyu leaves, 5.2% micro ingredients. The diet was prepared using the research mill and costs of making the feed calculated.

6.1.7 Develop on-station a range of best-bet feeding options for indigenous poultry, hybrid and Australorp production and profitability (project extension)

Two concentrate rations for laying hens were formulated; one that could be fed with sweet potato and the other with cassava. The sweet potato diet (HELC + SP) had an apparent metabolisable energy (AME) of 11.8 Mj/kg and contained 40% of cooked sweet potato. The specifications of the concentrate diet when mixed with cooked sweet potato diet were; CP (17.2%), total fat (3.9%), fibre (7.5%), calcium (3.4%) and phosphorus (0.7%). The cassava (40% inclusion rate) diet (LELC+ C) specifications were AME (10.9Mjcal/kg); CP (16.9%), total fat (3.8%); fibre (4.6%), calcium (3.3%) and phosphorus (1.0%).

To test these diets laying hen facilities at NARI in Lae, PNG were used. The study was conducted to evaluate the egg production performance of 3 different layer strains fed two concentrate diets blended with sweet potato or cassava. These test diets were compared with a control layer diet. A total of 42 Village hens, 42 Hyline Brown strain and 42 crossbred hens (Australorp x Hyline Brown) were randomly assigned to 18 pens in a naturally ventilated layer shed. Each pen housed 7 birds with each genotype having a similar body weight range. The 3 diets were evaluated using a randomized block design with 2 blocks and 3 genotypes by diet combination. Performance of birds (egg production, FCR, egg weight, feed intake and body weight) was monitored from 26-36 weeks of age. ANOVA was used to analyse the data.

Following the on-station layer trial at NARI region-specific grow-out trials at CLTC in the highlands and LDS in the lowlands were conducted to develop knowledge on the performance of layers fed the C and SP based diets.

The first trial was conducted over a 14 week period at the CLTC layer facility at Banz in the Jiwaka Province. Training of CLTC colleagues on how to run the trial was conducted by NARI staff. Hyline Brown layers (26 weeks of age) were allocated to 12 floor pens in naturally ventilated shed. Each pen had a bell drinker and a cylinder feeder and housed 10 birds. The design used was a completely randomized block with 2 blocks and 2 replicates in each block. There were 3 treatments diets; 1) HELC + SP; 2) LELC + C and 3) commercial layer ration. The eggs were collected daily, weighed and recorded. The body weight of birds was measured weekly and the bedding was changed weekly. Performance of birds (egg production, FCR, egg weight, feed intake and body weight) was monitored from 26-40 weeks of age. ANOVA was used to analyse the data.

The second trial was also undertaken at the CLTC facility using 30 Australorp crossbred layers. The layers were allocated 5 a pen into 6 floor pens using the same facility as described above. The two experimental diets were the LELC+ C and the HELC + SP diets fed as a wet mash. The commercial layer diet was fed as the control in this experiment. The diet treatments were replicated twice using a completely randomized design. Nest boxes were provided in each pen and feed and water were given ad libitum. Daily egg production, egg weight, feed offered and feed residues were recorded. The trial was conducted over eight weeks from 26-34 weeks. The data was analysed using ANOVA.

The third regional trial was conducted in the lowlands with village chickens at the LDS Centre in Malahang, Lae. Before the experiment, a hands-on training session was facilitated by the NARI Livestock research team for participants from LDS, including stock persons, motivators and organizers.

Fourty indigenous village chickens (26 weeks of age) with similar body weights were randomly allocated to 8 floor pens in a naturally ventilated layer house; each pen had a floor space of 9 m^2 with 5 birds in each pen. Each pen had a bell drinker and a cylinder feeder. The experimental used a completely randomized design with 2 replicates for each diet. There were 3 diets tested; 1) HELC + SP; 2) LELC + C and 3) commercial layer ration. Performance of birds (egg production, FCR, egg weight, feed intake and body weight) was monitored from 26-34 weeks of age. ANOVA was used to analyse the data.

6.2 Objective 2: To evaluate broiler production and profitability on-farm of various feeding options that incorporate local feeds

6.2.1 Train extension staff

Standard operating procedures were documented to conduct and monitor the on-farm activities. CLTC, LDS, Ok Tedi and SA staff were trained in on-farm evaluation studies.

6.2.2 Establish demonstration trials with farmers

On-farm village demonstration sites for broilers were selected by CLTC and SA in highlands, LDS in lowlands and OK Tedi in the Western Province. During the village trials the farmers worked closely with NARI and the NGO’s to validate and demonstrate the broiler feeding system. This activity involved training in the methodology required to operate a field trial and capacity building of the farmers during the visits made by NGO and NARI staff. The training of 50 livestock farmers, extension staff and technicians was completed. A number of trained farmers have supported other farmers to run trials not directly involved in the project.

6.2.3 Monitor the performance of the broilers, inputs and costs, and sale price to assess profitability of various feeding options

Cost of production models were developed to assess the profitability of feeding options. The first analysis was to derive the price of a mini-mill produced high protein concentrate. The 3 steps involved were; 1) derivation of a fixed asset annual overhead cost, 2) annual running costs, and 3) raw material feed costs.

Fixed asset annual overhead cost included land, fence, sheds; compacted gravel entry and mini-mill (hammer mill, electric or diesel motor, drying/roasting cauldron, mixer, pelleter, scales, power supply, cutting and handling tools, storage and pallet movers; office equipment, storage containers and a second hand vehicle). These assets were amortised over a number of years depending on type.

Annual running costs included fuel, municipal rates, power, phone, security, office supplies, pest control, skilled manual labour, repairs and maintenance.

Raw material feed costs included fishmeal, copra meal, palm kernel meal, coconut oil, low cost by-products (mill run) and premix (vitamins and amino acids).

Commercial feed prices were obtained from retail outlets in the highlands and lowlands. The cost of a commercial concentrate was based on grain legume prices being at least 50% more than feed wheat prices, together with an assumed higher cost for smaller mill batch runs.

Benefit-cost analysis of the economic impact of the R & D investment made by ACIAR and partners on the broiler program since 2001 was analysed using the DREAM program V3.0.0 (Wood, You and Baitx 2001). The program was run in the “closed economy” mode, as all village grown broilers are consumed within village or town communities, mostly through live bird sales in local markets.

6.2.4 Objective 3: To evaluate indigenous poultry, imported hybrid layers and Australorp production and profitability on-farm of various feeding options that incorporate local feeds (project extension)

Following the NARI and NGO layer feed evaluation, on-farm trials were conducted in the highlands and the lowlands. In the lowlands, the Amale area in the Madang province was selected to evaluate the LELC + C ration compared to the commercial ration. Seven farmers who kept village hens were selected to run the trial; 4 farmers were women, 2 were young males and 1 was an elderly man. All of these farmers were mostly involved in broiler and village chicken farming. One pen of 5 birds on each farm was fed the commercial ration while the other pen was fed the LELC+C. There were visits by NARI staff to set up the trial and during the trial to check on the progress of the trials. Any problems/difficulties encountered during the trial period were noted and explained and solved. Performance of birds (egg production, FCR, egg weight, feed intake and body weight) was monitored from 26-34 weeks of age. ANOVA was used to analyse the data.

In the highlands, the on-farm trials compared the performance of Australorp crosses and commercial layers (Hyline Brown) fed the HELC + SP and a commercial layer diet from 19-27 weeks of age. The feeding trials using Australorp crosses were conducted with 3 farmers; one each in the Simbu province, Tambul and Domil. In the Jiwaki province commercial Hyline Brown layers on the diets were trialled by 3 farmers and also by one farmer at Tambul. One pen of 5 birds on each farm was fed the commercial ration while the other pen was fed the HELC + SP. Performance of birds (egg production, FCR, egg weight, feed intake and body weight) were monitored during the trial and ANOVA was used to analyse the data.

6.3 Objective 3: To promote the wide-spread adoption of alternative feeding options for broilers that will improve profitability (including extension)

6.3.1 Produce and up-date information for use in NGO extension service leaflets and village training material

6.3.1.1 Fact sheets

Draft one-page information leaflets on best practice feeding methods for village poultry **(broilers and layers)** were developed by SARDI and NARI. The leaflets show pictures of the feed ingredients, how they are prepared, and the amount of local sweet potato or cassava to include in the diet and how the diet is fed to birds.

6.3.1.2 Newsletters

Newsletters from NARI (Didinet News) were disseminated to partners with a focus on outputs from the project. Poultry handouts provided basic management advice for interested farmers and were also given to students.

6.3.1.3 Radio

Many village farmers maintain regular contact with NGO's via extension visits and via advice given by officers on local radio. Training information was also provided to farmers over the radio.

6.3.1.4 Handbooks

NARI and the NGO's distributed various handbooks and farmer's booklet. Information generated from various poultry projects was included for distribution to village farmer networks.

6.3.1.5 Video Production

A video script was written with a village farmer being shown how to feed broilers in the traditional manner using commercial feed. An extension officer visits a village farm with a bag of concentrate. The officer shows the farmer how to cook local vegetables and mix it in with the concentrate. The audience for the video are village farmers in PNG and other Pacific Islands (see appendix 5 for details of the script).

6.3.2 CLTC and LDS poultry production curriculum

Fact sheets for local feed ingredients in PNG were developed by SARDI and made available to partners to include in the curriculum. The fact sheets contain the name, general description, chemical composition, nutritive value and anti-nutritional factors for each ingredient. The fact sheets also provided guidelines on the use of these ingredients in poultry diets. This information was obtained from journals, books, internet and feed ingredient tables.

6.3.3 Conduct annual workshops for NGO’s for briefing about on-station and on-farm activities

The first annual review meeting was held at CLTC, Banz Campus from 29-30 July 2009 and was attended by 15 participants representing NARI, Salvation Army, UniTech, LDS, Project Support Services and SARDI. A poultry workshop titled "Improving Poultry Production in Developing Countries in SE Asia and the Pacific Region" was run at the CLV Conference Centre, University of Sydney Village from 4-5 February 2009. The workshop was funded by AusAid, WPSA, Australian Egg Corporation Limited, Biomin, Chemin and Aviagen. The workshop was attended by participants from East Timor, PNG, Solomon Islands and Tonga who had previously or are currently involved with ACIAR poultry feed projects.

The second annual review meeting was held on 11 November 2010 in the Allan Quartermain Hall in Lae, PNG. The meeting involved 31 people including project participants from SARDI, NARI, LDS, OK Tedi, CLTC, Project Support Services and representatives from ACIAR, Presidents of the World and Australian body of the WPSA, DAL (Highlands, Fisheries and Madang) and industry representatives from Goodman Fielder International, NGTB and Crest Mills (Fiji). At both meetings briefings were given on progress with projects and the success being achieved with the concentrate feeding systems.

The third annual review meeting took place in the Allan Quartermain Hall, Lae, PNG on 21 February 2012 to further assess progress on the project. The meeting was attended by 28 participants in the project but also Emily Flowers (ACIAR PNG country manager) and representatives from NGTB and Zenag Poultry.

The final review meeting was held at the Momahi conference room in Lae on 29 November 2012 and was attended by 17 participants including Dr Caroline Lemerle (ACIAR ASEM Program Manager). This final review meeting was followed by an adopt workshop led by Geoff Kuehne (CSIRO) and Roger Wilkinson (VicDPI). The workshop was conducted to determine if the broiler feeding system was suited to PNG village poultry operations and the extent of adoption of the feeding system in the highlands, lowlands and outer islands of PNG

6.3.4 Assist NGOs in a coordinated campaign promoting the use of lower cost feeding regimes

The campaign targeted farmers through on-site training, field days, promoting the feeding system at schools, articles in newspapers and distribution of fact sheets.

7 Achievements against activities and outputs/milestones

Objective 1: To develop on-station a range of best-bet feeding options for broiler production and profitability.

No	Activity	Outputs/ milestones	Completion date	Comments
Note: Milestone completion adjusted for Aug 2007 after project inception (8 months late due to delays in signing contract by PNG partners)				
1.1	To develop on-station a range of best-bet feeding options for broiler production and profitability (P).	Low cost diets formulated	Yr 1, m 1	Milestone of formulating low cost diets was achieved on schedule. Low energy, medium energy and high energy broiler concentrate diets were formulated by Lae Feed Mills and NGTB nutritionists in consultation with SARDI scientists.
		Cheapest source of concentrate determined	Yr 1, m 1-2	Milestone of sourcing cheapest concentrate was completed on time. Lae Feed Mills and NGTB provided the concentrate competitively priced using least cost feed formulation.
		Mill operators trained	Yr 1, m 1-3	Milestone of training mill operators achieved on schedule. This activity was undertaken initially with a fisheries feed workshop and then in conjunction with the project inception meeting and later with training of Domil staff. Project Support Services Ltd in Lae (with support from SARDI staff) conducted training for PNG and Tongan staff
		AME of diets completed at NARI	Yr 1, m 1-3	AME milestone was completed on schedule. AME and dry matter digestibility was used to assess the diets nutritive value. The results indicated that sweet potato ideally should be fed with the low energy concentrate and cassava fed with the high energy concentrate.
		Broiler grow-out trials completed at NARI	Yr 1, m 4-6	On-station grow out trials were completed by NARI on schedule. Four diets were tested; 1) 50% sweet potato and 50% low energy concentrate; 2) 70% sweet potato and 30% low energy concentrate; 3) 50% cassava and 50% high energy concentrate and 4) 70% cassava and 30% low energy concentrate. Final body weights of birds on diets 1-4 were 2.47, 2.38, 2.23 and 1.81kg respectively.

		4 low cost concentrate diets (2 for highlands, 2 in lowlands) recommended for testing at LDS and CLTC	Yr 1, m 7	Based on the results it was recommended that 3 diets be tested in the highlands at CLTC and in the lowlands at LDS and at Ok Tedi in the Western Province rather than 2 diets for the highlands and 2 for the lowlands as originally intended. The diets tested at the NGO facilities included; 1) 50% sweet potato and 50% low energy concentrate; 2) 70% sweet potato and 30% low energy concentrate; 3) 50% cassava and 50% high energy concentrate
1.2	Establish on-station grow-out facilities at LDS (lowlands) and at CLTC (highlands) including protocols and training for the conduct of trials. (P)	Broiler grow-out facilities constructed at LDS and CLTC	Yr 1, m 1-2	Grow-out facilities at LDS, CLTC and Ok Tedi were constructed on schedule using the design recommended by SARDI
		LDS and CLTC staff trained to conduct on-station trials	Yr 1, m 1-5	Staff training was completed on schedule at LDS, CLTC and Ok Tedi by NARI's Janet Pandi and Janet Deklin.
		Grow-out protocols completed and understood by staff at LDS and CLTC	Yr 1, m 6	Grow out protocols provided to LDS, CLTC and Ok Tedi were completed and a pre trial grow out under the direction of NARI scientists was completed.
		Staff understand how to feed poultry concentrate with local carbohydrate resources	Yr 1, m 6	NARI staff conducted training at LDS, CLTC and Ok Tedi as scheduled.
1.3	Undertake region-specific grow-out trials to develop local knowledge and refine best-bet options for testing on-farm. (P)	Design of broiler grow-out trials completed for LDS, CLTC and Ok Tedi	Yr 1, m 7	Trial design was completed on schedule. The experiment involved a control commercial diet vs. the 3 treatment diets. A randomised block design with 4 replicates per treatment was used.
		Broiler grow-out trials completed at LDS and CLTC	Yr 1, m 8-10	Trials at LDS, CLTC and Ok Tedi were completed one month behind schedule

		Report completed recommending 2 best-bet feeding options both for the highlands and lowland	Yr 1, m 11	The diet with the greatest potential in the Western Highlands Province was 50% of a low energy concentrate supplemented with 50% of sweet potato; the diet best suited for lowland chicken meat production is 50% high energy concentrate supplemented with 50% cassava while in the Western Province poultry grew equally well when fed a poultry concentrate supplemented with 50% cassava or 50% sweet potato.

PC = partner country, A = Australia

Objective 2: To evaluate broiler production and profitability on-farm of various feeding options that incorporate local feeds

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Train extension staff from CLTC, LDS, Ok Tedi and SA and students from UniTech in the conduct and monitoring of on-farm evaluation studies. (P)	Pilot trial farm selected for village grow-out trial	Yr1, m 12	CLTC, LDS and Ok Tedi staff were trained at their demonstration centres by NARI and SARDI staff
		Pilot village trial completed	*Yr 2, m 1-2*	Pilot grow out trial completed at CLTC and LDS instead of village site
		Grow-out protocols completed and understood by staff at LDS, CLTC, Unitech and NARI	*Yr 2, m 3*	Grow-out protocols were developed by NARI and SARDI scientists and understood by staff from NGO's
2.2	Establish up to 10 demonstration trials with farmers in the highland and lowland provinces using feed combinations developed in consultation with the individual farmers. (P)	Pilot trial farm selected for village grow-out trial	Yr1, m 12	Trial farms selected in highlands, lowlands and western province.
		Pilot village trial completed	*Yr 2, m 1-2*	The pilot trials were not necessary and were run as major trials reported below.

		Grow-out protocols completed and understood by staff at LDS, CLTC, Unitech and NARI	*Yr 2, m 3*	Grow-out protocols were developed by NARI and SARDI scientists and were understood by staff from NGO's who ran village trials with support from SARDI and NARI
2.3	Monitor the performance of the broilers, inputs and their cost, and sale price in order to assess the acceptability and profitability of various feeding options. (P)	First 2 village grow-out trails established in highland and lowlands	Y2, m 7	The village grow out trials in the highlands, lowlands and in the Western Province were run at Mahalang, Finschafen and Madang in the lowlands; in the Banz and Kainantu districts in the highlands and at Kiunga, Star Mountains and Tabubil in the Western Province. The trials were supervised by NARI and SARDI in collaboration with CLTC, LDS, SA, and Ok Tedi.
		First 2 village trials completed in highlands and lowlands	Y2, m 8-10	The results of all the village grow out trials in the highlands, lowlands and in the Western Province showed that birds reached market weight (>2 kg) soon after 5 weeks of age. The sweet potato based diet (in particular) compared very favourably with the commercial control diet.
		Production and economic evaluation of data completed for first 2 village trials in highlands and lowlands	Y2, m 8	Models were developed based on PNG milling equipment and ingredient costs for; 1) running a mini-mill operation to produce poultry concentrate and 2) determining the profitability of a village broiler enterprise.
		Production and economic evaluation of data completed for first 2 village trials in highlands and lowlands	Y2, m 11	The objective of the economic assessments was to provide a cost for locally milled broiler rations compared to the price of the commercially available alternative, at several key sites in PNG. Spreadsheets of mini-mill operations and village broiler grow-out operations were developed. Staff from NARI and Unitech collected feed ingredient costs and other fixed costs to populate the spreadsheets.
		Report completed on production and economic evaluation of village trials for the first 2 demonstration trials in the highlands and lowlands	*Y2, m 12*	The economic analyses were completed for all village poultry trials undertaken. The cheapest carbohydrate source to feed broilers in the highlands is sweet potato while in the lowlands cassava is preferred. Comparisons were made of the costs of the following feeding options; 1) lowlands mini-mill HEC (50%) supplemented with cassava (50%); 2) lowlands commercial HEC (50%) supplemented with cassava (50%); 3) lowlands commercial feed (50%) diluted with copra meal (50%) and 4) lowlands commercial feed. In the highlands the costs of the same feeding options were determined except sweet potato was used instead of cassava.

		Final 3 village grow-out trails established in highlands and lowlands	*Y3, m1*	The lowland broiler farmers are close to the commercial mills while the highland farmers have extra costs associated with transport of commercial feed. The feeding costs in both the highlands and lowlands show advantages when concentrates are fed with sweet potato or cassava compared to use of commercial broiler finisher feed based on imported ingredients.
		Final 3 village trials completed in highlands and lowlands	*Y3, m 2-3*	The proportion of the costs of the concentrate and dilution feeding system relative to using commercial feeds alone show that there is a strong cost reduction incentive at the village level to adopt alternative feeding strategies based partly or wholly on local feed ingredients
		Production and economic evaluation of data completed for final 3 village trials in highlands and lowlands	*Y3, m 4*	It is possible to achieve feed cost savings of up to 35%, with the mini-mill concept being the most advantageous. The mini-mill concentrate was based on copra, fishmeal and coconut oil while the commercial concentrate was based on imported ingredients.
		Report completed on production and economic evaluation of village trials for final 3 village trials in the highlands and lowlands	*Y3, m 5*	An ex-ante benefit-cost analysis of the economic impact of the R, D & E program to improve the profitability of village broiler production in PNG was carried out. The research and development aspects of the program have developed a mini-mill approach for the provision to villagers of a high protein concentrate based on local feed sources. However, other options include a commercial high protein concentrate plus local carbohydrate source and a dilution strategy of half normal commercial feed plus local carbohydrate source.
		Cost of production model developed by Unitech and SARDI economists recommends diets suitable for improving the profitability of village broiler production in PNG	*Y3, m 6-7*	The estimate of the program costs was 3.3 M kina. On the core assumption of 35 percent market penetration of these new technologies, the analysis showed an internal rate of return to the program of 25 % p.a. and a net present value of 45.6 M kina. The benefits were attributed to a producer surplus of 16.3 M kina and a consumer surplus of 32.7 M kina.

PC = partner country, A = Australia

Objective 3: To promote the widespread adoption of alternative feeding options for broilers that will improve profitability.

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Production and/or updating of information for use in NGO extension service leaflets and village training material. (P)	Meeting of project participants completed. Sub committee appointed to update extension materials	*Y 3, m 8*	Fact sheets were prepared illustrating (in pictorial form) the method to prepare concentrate diets using mini mills and how farmers can feed these diets with sweet potato or cassava on village farms
		Extension materials completed and published	*Y 3, m 9-10*	The fact sheets were translated into pidgin and have been made available to all partners at project meetings at NARI and NGO workshops, trade fairs and WPSA meetings.
3.2	Assist in the development of the CLTC and LDS poultry production curriculum. (P)	Poultry curriculum completed that promotes best-bet feeding methods for improving profitability of village broiler production	Yr 3, m 11	The poultry curriculum resource material demonstrates the concentrate feeding system and provides a general guideline for the use of feed ingredients for poultry in PNG. The feed ingredients include maize, sorghum, wheat, sweet potato, cassava meal (leaf and root), banana, legume leaves, wheat mill run, rice bran, palm kernel meal, pyrethrum marc, fish meal, soybean meal, leucaena meal, amaranth, sunflower meal, pigeon pea, fresh coconut, mung bean, cow pea, cabbage, pigeon pea leaves, pawpaw leaves and fruits and green pigeon pea. The curriculum resource material contains the name, general description, brief details on nutritive value and anti-nutritional factors for each ingredient.
		Students complete training with new poultry curriculum	Y3, m 12	Feeding trials using the fact sheets developed in the trial were run at 2 schools in the highlands
3.3	Conduct annual workshops for NGO's for briefing on on-station and on-farm activities and to receive feedback on their farmer experiences.(P)	Annual workshops conducted and recommendations from meetings published	Y1, m 12 Y2, m 12 Y3, m 12 Y4, m 12	Y1 Annual workshop completed in July 2009 Y2 Annual workshop completed Nov 2010 Y3 The third annual review completed February 2012 Y4 final review meeting and adopt workshop was completed November 2012
3.4	Assist NGO's in a coordinated campaign promoting the use of lower-cost feeding regimes, building on the outcomes of the farmer demonstration trials. (P	Meeting recommends campaign required to improve profitability of village broiler production. Campaign committee appointed	Y3, m 8	At the annual workshop in Lae in Nov 2010 a campaign to publicise the benefits of the broiler feeding system in PNG was commenced. These included field days, training and demonstration sessions run by NARI and other NGO partners and distribution of publications (tok toks, bulletins and fact sheets).

		Campaign strategy implemented in PNG	Y3, m 12	NARI and partners also promoted the broiler feeding system via radio and TV programs. Likewise a number of newspaper articles and reports on the NARI website were published. Fact sheets of feed resources available in PNG for broiler feeding were developed for College, University and NGO curriculums and a video script detailing how to use the feeding systems was written and filmed for playing at field days.

PC = Partner Country, A = Australia

Project extension- evaluating the poultry concentrate feeding system for laying hens

Objective 1: To develop a commercial mini mill enterprise

No.	Activity	Outputs/ milestones	Completion date	Comments
1				
1.1	Activity 1. Establish mini mill enterprise (P).	Mini mill identified	Y4, m 3	Domil Community mill was selected by NARI as a good model to demonstrate a mini mill enterprise. NARI also developed their own research mini mill
		Advice and training provided to mix concentrate diets	Y4, m 5	NARI staff supported the training of Domil staff to run the mini mill enterprise to manufacture concentrate feed for sale to village farmers.
1.2	Activity 2 Monitor the cost and income (P).	Commercial diets available for sale	Y4, m 9	First concentrate diets were manufactured and sold to village broiler farmers. The mill was opened on 4 April 2012
		Business model for Domil mill established	Y4, m 12	The savings in feed costs at the Domil mini mill were 12% compared to using commercial feed.

Objective 2: To develop on-station a range of best-bet feeding options for indigenous poultry, commercial hybrids and Australorps.

No.	Activity	Outputs/ milestones	Completion date	Comments
2	Activity 1 Assess layer diets at NARI (P).	The layer diets assessed for their suitability in village layer production using the layer facilities at NARI.	Yr 4, m 12	The village hens had the lowest production while the Australorp cross achieved consistently higher egg production compared to the commercial hybrid but this was due to the high levels of cannibalism and feather pecking in the commercial layers.
	2.2 Select layer diets for NGO trials (P).	Low cost diets suitable for highland and lowland trials selected	Y5, m 1-3	The sweet potato diet (HELC + 40% SP) and the cassava diet (LELC + 40% C) were selected for testing in the highlands and lowlands

Objective 3: To evaluate layer production and profitability on-farm of various feeding options that incorporate local feeds.

no.	Activity	Outputs/ milestones	Completion date	Comments
3	Activity 3.1 Supervise extension staff from CLTC, LDS, OTDF during layer trials (P)	Staff trained in how to run layer trials	Yr5, m 1	Training of NGO colleagues on how to run layer trial was conducted by NARI staff.
		Layer trials completed	Yr 5, m 2-3	The commercial hybrids at the CLTC site fed the SP and C based rations had lower feed intake relative to the control birds, they produced fewer eggs and had lower egg weight but feed conversion was superior. At the LDS site, village hens fed on SP and C based rations had higher egg production compared to birds fed on the commercial ration but had poorer feed conversion.
3	Activity 3.2 Establish up to 5 demo layer trials with farmers in the highland and lowlands (P)	Trial farms selected for layer trials	Yr 5, m 3	Following on from the on-station and NGO feeding trials, on-farm trials were selected in the highlands and in the lowlands. In the lowlands the LELC+C diet performed better than the commercial diet when assessed on the basis of average egg weight and FCR.
		Village trials completed	Yr 2, m 4-6	The farmers were very pleased with the performance of the birds fed the LELC+C diet. At the official closing of the on-farm trials, there was a high turn up mostly of women, youth and village elders who wished to get further involved.
2.3	Monitor the performance of the layers, inputs and their cost, and sale price to profitability of feeding options. (P)	Production and economic performance of village layer trials evaluated	Y2, m 6	On the basis of cost it was determined that the most affective feeding option for layer type birds was the SP based diet. The commercial layer concentrate was the most costly.

8 Key results and discussion

8.1 Objective 1: To develop on-station a range of best-bet feeding options for broiler production and profitability.

8.1.1 Develop combinations of low cost concentrate diets fed with different PNG feed resources.

The birds fed the Lae Feed Mill commercial broiler diets had higher feed intake and weight gain and better FCR's than all other diets (Table 1). However birds fed the SP70L diet performed well and had higher weight gain compared to birds fed the other concentrate diets. The birds fed on CAS70L diet had the poorest performance. Birds fed the SP70H had lower gains then those fed on the SP70L diet. Clearly the high energy content of sweet potato diminishes the need to use the high energy concentrate. DMD coefficients (Table 1) were similar for all test diets but the AME of the diets (Table 1) reflected the calculated values obtained when formulating the diets.

The two best feeding regimes based on AME (Table 2) and DMD results were a 1:1 ratio (dry matter basis) of cassava fed with a high energy concentrate and a 1:1 ratio of sweet potato fed with a low energy concentrate.

Table 1. Production parameters of broilers in AME trial; control vs. concentrate + sweet potato or cassava

Diets	End weight (Kg)	Weight gain (Kg)	Intake (Kg)	FCR	DMD
LFM starter	1.228a	0.412a	1.037a	2.52e	0.412a
LFM Finisher	1.200a	0.393a	1.026a	2.61e	0.405a
CAS70H	0.993c	0.193c	0.936bc	4.92c	0.490a
SP70H	0.912d	0.125d	0.865d	7.26a	0.381a
CAS70M	0.958c	0.180c	0.942bc	5.22c	0.451a
SP70M	0.953c	0.180c	0.901c	5.02c	0.409a
CAS70L	0.892d	0.155cd	0.926bc	6.11b	0.467a
SP70L	1.052b	0.249b	0.955b	3.89d	0.450a
LSD (5%)	40.3	38.9	46.9	0.83	0.30
P-Value	<.001	<.001	<.001	<.001	0.374

Means with a common letter within a column are not significantly different (P > 0.05)

(LFM = Lae Feed Mills; H = High Energy Concentrate; M = Medium Energy Concentrate and L = Low Energy Concentrate); SP = sweet potato; CAS = cassava; DMD = Dry matter digestibility; FCR = feed conversion ratio

Table 2. AME and nutritive values of the diets fed in the trial conducted by NARI at Labu

Experimental Diets	AME (Mj/Kg)	Protein (%)	Fat (%)	Fibre (%)	Lysine (%)	Methionine (%)	Met + Cys (%)
HEC + 70% C	15.64	14.96	3.06	4.39	1.01	0.53	0.67
HEC + 70% SP	15.57	15.59	2.92	0.96	6.41	0.50	0.65
MEC + 70% C	15.63	13.37	0.78	3.43	1.69	0.03	0.01
MEC + 70% SP	15.10	16.15	1.94	1.19	6.55	0.58	0.74
LEC + 70% C	15.00	14.45	2.07	4.83	1.02	0.55	0.69
LEC + 70% SP	14.93	15.08	1.93	1.40	6.43	0.52	0.67

8.1.2 Train operators of regional mini-mills in formulation and feed mixing

Staff involved in the poultry project participated in 2 feed manufacturing workshops. A major aim of the first feed manufacturing workshop was to couple the theoretical information of lecture material to the practical aspects of formulating, making and storing farm made feeds. In order that all participants gained as much practical feed making experience as possible, they were broken into four smaller groups and assigned a different task. Groups were assigned a formulation exercise that required them to weigh, mix, pellet and dry 1 kg of a formulated diet; other groups were given the opportunity to review and discuss feed making equipment and machinery.

Each of the groups enjoyed making their feeds and successfully produced pellets. These feeds were labelled and placed in a solar dryer for review the following day. Wet samples of each feed were also taken, stored in airtight containers and refrigerated. As expected, there was some variation in the quality of pellets produced by each group, mostly due to moisture content. These differences provided a useful basis for contrasting the quality of each feed the following day.

All feeds were displayed on feeding trays and samples of wet and dry feed were also immersed in water to study pellet water stability. Participants were asked to review the feeds and discuss differences between each group. Group discussion included use of starchy binders to increase feed and water stability, use of more powerful pellet making equipment and changes to formulations that can increase or decrease the bulk density of feeds. The feed manufacture provided staff the skills to make pelleted feed.

Staff involved in the poultry project also attended a second feed making workshop in Lae at Project Support Services. Participants were provided knowledge on how to mix a concentrate diet and how to use flake mills, hammer mills, dryers, pelleters and mixers. (Appendix 3)

Prior to the launch of the Domil mini mill, 2 representatives from 7 community groups were chosen to undergo training in food and feed processing and basic poultry husbandry skills. The feed processing training covered husbandry and management of broilers using the concentrate developed in the project. A total of 14 participants were trained by 5 NARI scientists over two weeks and were able to manufacture feed for broilers with sweet potato and cassava as the main dietary ingredient.

NARI staff prepared a concentrate diet from local ingredients comprising 26.8% fish meal, 32.2% soybean meal, 15.8% cassava leaves, 14.7% maize, 3% copra meal, 2.3% kikuyu leaves and 5.2% micro ingredients. The cost of the concentrate plus sweet potato was 8.10K/bird; the commercial concentrate was 9.33K/bird and commercial finisher 10.07K/bird. Meat birds fed the Labu formulation had similar FCR to birds fed the commercial concentrate. The feed milling exercise at Labu proved that local concentrates can be prepared using mini mills.

8.1.3 Feeding options identified for highlands and lowlands

The statistical analysis showed that FCR achieved by birds fed cassava and sweet potato depended on whether it was fed with high, medium or a low energy concentrate. The two best bet feeding regimes based on the AME results (Tables 1 and 2) were to feed cassava with a high energy concentrate and sweet potato with a low energy concentrate. The feeding options that were tested in a grow-out trial at NARI were; 50% SP with 50% LEC; 50% C with 50% HEC; 70% SP with 30% LEC and 70% C with 30% HEC.

The test diets were compared with a commercial broiler finisher feed produced by NGTB. The grow out experiment consisted of 5 diets with four replicates of each diet. There were a total of 20 birds in each replicate with an equal number of females and males. From day 1-21, the broiler chickens were fed with a starter crumble feed. The experimental diets were used from day 21-49. There were high mortality levels in the control diet after 35 days.

Table 3. Weekly body weight (kg) of birds fed 5 diets; control vs. concentrate + sweet potato or cassava at NARI

Age (weeks)	Overall mean	NGTB	SP50L	CAS50H	SP70L	CAS70H	LSD (5%)	P Value
3	0.906	0.904a	0.906a	0.907a	0.903a	0.909a	0.012	0.838
4	1.177	1.269a	1.219b	1.236ab	1.075c	1.086c	0.041	<.001
5	1.540	1.855a	1.587b	1.531c	1.488c	1.238d	0.055	<.001
6	1.892	2.558a	1.810b	1.875b	1.719b	1.500c	0.214	<.001
7	2.321	2.709a	2.473ab	2.384b	2.231b	1.809c	0.241	<.001

Means with a common letter in a row are not significantly different (P>0.05).

NGTB diet, SP50L = SP + 50% LEC; CAS50H = C + 50% HEC; SP70L = SP + 50% LEC; CAS70H = Cassava + 70% HEC.

As expected the birds on the control diet had significantly higher (P<0.001) weight compared to all experimental diets. Birds fed the SP50L diet, had the second best body weight compared to the control diet, followed by birds fed the CAS50H and then the birds fed the SP70L diet (Table 3). The birds fed the CAS70H diet had the lowest (P<0.001) body weight of all the diets. Nevertheless birds on the experimental diets, SP50L, CAS50H and the SP70L were able to reach a market weight of 2 kg by week 7 which is economical for village farmers.

The weight gain of birds on the control diet were significantly higher (P<0.001) in weeks 4 and 5 compared to birds on the experimental diets (Table 4). However, in week 6, birds fed the CAS50H diet had significantly higher gain (P<0.002) compared to all other diets, but by week 7, gains of birds on the SP50L were significantly higher (P<.001) than on all other experimental diets (Table 4). The birds on the control diets reached a bodyweight where they were unable to cope with the environmental temperature.

Table 4. Weekly body weight gain (kg) of birds fed 5 diets; control vs. concentrate + sweet potato or cassava at NARI.

Age (weeks)	Overall mean	NGTB	SP50L	CAS50H	SP70L	CAS70H	LSD (5%)	P Value
4	0.271	0.365a	0.313b	0.330ab	0.172c	0.177c	0.038	<.001
5	0.363	0.586a	0.368b	0.295c	0.413d	0.152e	0.030	<.001
6	0.258	0.269b	0.212bc	0.344a	0.201c	0.263bc	0.062	0.002
7	0.443	0.223c	0.663a	0.509b	0.512b	0.309c	0.115	<.001

Means with a common letter in a row are not significantly different (P>0.05).

NGTB diet; SP50L = SP + 50% LEC; CAS50H = C + 50% HEC; SP70L = SP + 50% LEC; CAS70H = C + 70% HEC.

Table 5 shows that birds fed the CAS70H diets had significantly lower (P<0.001) feed intake compared to intake of birds on all other experimental diets. With the exception of the control diet, birds fed diets comprising sweet potato (SP50L and SP70L) had higher intakes than those on the cassava diets.

Table 5: Weekly feed intake (kg) of birds fed 5 diets; control vs. concentrate + sweet potato or cassava at NARI.

Age (weeks)	Overall mean	NGTB	SP50L	CAS50H	SP70L	CAS70H	LSD (5%)	P Value
4	0.717	0.733a	0.750a	0.704a	0.750a	0.648b	0.048	0.002
5	0.860	1.153a	0.894b	0.763c	0.897b	0.593d	0.041	<.001
6	0.911	1.445a	0.814b	0.694b	0.991b	0.612b	0.364	0.002
7	0.858	0.924b	1.069a	0.797c	0.969b	0.530d	0.088	<.001

Means with a common letter in a row are not significantly different (P>0.05).

NGTB diet; SP50L = SP + 50% LEC; CAS50H = C + 50% HEC; SP70L = SP + 50% LEC; CAS70H = C + 70% HEC.

The FCR values of broilers on experimental diets were significantly different throughout the experiment (Table 6). In weeks 4 and 5, the birds on the control diet had better FCRs compared to other diets, but in week 7, birds on the SP50L diets had significantly lower (P<0.042) FCR compared to other diets except for the control diet. The FCRs of birds on the CAS70H diet improved from week 4 to week 7, whilst birds on the SP70L diet improved from week 4 to week 7. This improvement in FCR may be due to adaptation of birds to the experimental diets.

The birds on the control diet at the end of week 7 had significantly higher FCR compared to all other diets presumably due to the impact of high environmental temperature on birds with high body weight.

Table 6: Weekly FCR of birds fed 5 diets; control vs. concentrate + sweet potato or cassava.

Age (weeks)	Overall mean	NGTB	SP50L	CAS50H	SP70L	CAS70H	LSD (5%)	P Value
4	2.935	2.017c	2.410c	2.147c	4.404a	3.699b	0.4857	<.001
5	2.644	1.969c	2.433bc	2.587b	2.173bc	4.059a	0.5646	<.001
6	3.740	5.491a	3.854b	2.077c	4.944ab	2.345c	1.450	<.001
7	2.470	5.483a	1.620b	1.625b	1.907b	1.713b	2.814	0.042

Means with a common letter in a row are not significantly different (P>0.05).

NGTB diet; SP50L= SP + 50% LEC; CAS50H = C + 50% HEC; SP70L = SP + 50% LEC; CAS70H = C + 70% HEC.

The options of feeding cassava with a high energy concentrate and sweet potato with a low energy concentrate were promising. Birds fed the SP50L, CAS50H, SP70L and CAS70H were able to reach a market weight of 1.8-2.5kg by the end of week 7. The birds on the control diet had higher weight gain in weeks 4 and 5, but in weeks 6 and 7 the birds on the CAS50H and SP50L diets had higher gains. Birds fed the CAS70H diet had lower feed intake throughout the experiment along with a higher FCR values in the first two weeks after introduction to the diets. However the birds were able to convert better in weeks 6 and 7. The lower intakes may be associated with consuming energy dense diets. Broilers eat to satisfy their energy requirement which was supported with good weight gain and better FCR at the end of week 7. Diets with 50 and 70% sweet potato and 50% cassava were able to achieve a better performance. The combinations of 50% and 70% sweet potato with 50% and 30% low energy concentrates and 50% cassava with 50% high energy concentrate were then further tested with NGO partner facilities at regional sites to confirm the results obtained in the NARI grow out experiment.

8.1.4 Establish on-station grow-out facilities in the lowlands at LDS and at CLTC in the highlands at Ok Tedi in the Western Province, including protocols and training for the conduct of trials.

Grow-out facilities were established at NGO sites. Trial protocols were understood by local staff, particularly in how to mix concentrate diets with sweet potato and cassava. The grow out facilities established at CLTC, LDS and Ok Tedi enabled the NGO partners to undertake replicated trials and to develop the skills required to demonstrate the feeding system to village farmers. The NGO staff were also trained by NARI researchers on how to run a layer trial in Lae (LDS), Banz (CLTC) and Tabubil (Ok Tedi). The experimental protocols and data collection sheets provided were printed and handed over to the 6 staff attached to the project.

8.1.5 Undertake region-specific grow-out trials to develop local knowledge and refine best-bet options for testing on-farm.

There was a need to further evaluate the best bet-feeding options with partners to confirm the results obtained in the on-station grow out experiment conducted at NARI. The trials were run at partner sites and included Christian Leaders Training College (CLTC) in Banz, Western Highlands Province, Lutheran Development Services (LDS) in Morobe Province and the Ok Tedi Mining Limited in Tabubil, Western Province. Results for each site are shown individually and then later summarised.

Table 7. Average body weight (kg) of birds fed 4 diets; control vs. concentrate + sweet potato or cassava at CLTC.

Experimental Diet	Day 21	Day 28	Day 35	Day 42
NGTB broiler finisher	0.810	1.371a	1.988a	2.724a
SP50L	0.813	1.276a	1.735b	2.283b
CAS50H	0.813	1.221a	1.566b	2.082c
SP70L	0.810	0.906b	1.157c	1.514d
P-value	0.803	0.004	<0.001	<0.001
LSD	0.009	0.147	0.174	0.151
% CV	0.400	4.400	3.900	2.500

Means with a common letter in a column are not significantly different (P>0.05).

NGTB = New Guinea Table Birds; SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

By day 42 the birds at CLTC fed the commercial NGTB diet had a significantly higher (P<0.001) weight compared to birds on the local diets (Table 7). Birds fed the SP50L diet had higher weight than birds fed all other local diets.

Table 8. Weekly weight gain (kg) of birds fed 4 diets; Control vs. concentrate + sweet potato or cassava at CLTC

Experimental diets	Day 28	Day 35	Day 42
NGTB broiler finisher	0.559a	0.617a	0.736a
SP50L	0.463a	0.459b	0.548ab
CAS50H	0.409a	0.345c	0.516ab
SP70L	0.096b	0.251d	0.357b
P-value	0.004	0.001	0.045
LSD	0.152	0.086	0.231
% CV	14.400	7.400	15.400

Means with a common letter in a column are not significantly different (P>0.05).

NGTB = New Guinea Table Birds; SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

Weight gain for birds fed the SP70L diet was significantly lower (P<0.004) than the birds fed the other diets for weeks 4 and 5; however during week 6 weight gain was close to birds fed the SP50L and CAS50H diets (Table 8).

Table 9. Weekly feed intake (kg) of birds fed 4 diets; Control vs. concentrate + sweet potato or cassava at CLTC.

Experimental diets	Day 21	Day 28	Day 35	Day 42
NGTB broiler finisher	0.700	1.062a	0.997a	1.505
SP50L	0.700	1.072a	0.832b	1.350
CAS50H	0.700	0.962c	0.966a	1.385
SP70L	0.699	1.012b	0.828b	1.350
P-value	0.548	0.010	0.011	0.188
LSD	0.001	0.049	0.087	0.178
% CV	0.100	1.700	3.500	4.600

Means with a common letter in a column are not significantly different (P>0.05).

NGTB = New Guinea Table Birds; SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

During week 4, the birds fed the NGTB and SP50L diets in the CLTC trial had significantly higher (P<0.01) intake than birds fed SP70L and 50CAS/30HEC diets. By day 35, birds fed NGTB and CAS50H diets had significantly higher (P<0.01) intake than SP50L and SP70L. At the end of week 6 (day 42), feed intake of birds on all diets were similar (Table 9). It is clear that birds adapt to local diets at different rates but near market weights birds appear to benefit from local diets as it makes it easier for birds to thermoregulate when subjected to high temperature and humidity. In addition village broilers are usually sold live at a fixed price and any additional body weight gives no advantage on price.

Table 10. Weekly FCR of birds fed 4 diets; Control vs. concentrate + sweet potato or cassava at CLTC.

Experimental diets	Day 28	Day 35	Day 42
NGTB broiler finisher	1.913b	1.617b	2.074b
SP50L	2.084b	1.818b	2.472b
CAS50H	2.671b	2.827a	2.686b
SP70L	10.785a	3.325a	3.786a
P-value	0.004	0.020	0.006
LSD	3.150	0.951	0.613

% CV	26.000	14.300	8.000

Means with a common letter in a column are not significantly different (P>0.05).

NGTB = New Guinea Table Birds; SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

FCR of birds fed the SP70L diet in the CLTC trial was very poor on day 28 and significantly different (P<0.004) from birds fed the other diets. However by day 35, birds on the SP70L diet had a FCR which was not significantly different to birds on the CAS50H diet but still poorer (P<0.02) than birds fed on the NGTB and the SP50L diets. By day 42, birds fed the SP70L diet still had significantly poorer (P<0.006) FCR, compared to birds fed the other diets (Table 10).

Table 11. Weekly body weight of birds fed 4 diets; Control vs. concentrate + sweet potato or cassava at LDS.

Experimental diets	Day 21	Day 28	Day 35	Day 42
NGTB broiler finisher	0.801	1.477a	2.011a	2.724a
SP50L	0.800	1.318b	1.802b	2.342b
CAS50H	0.801	1.327b	1.860b	2.377b
SP70L	0.801	1.154c	1.454c	1.785c
P-value	0.651	<0.001	<0.001	<0.001
LSD	0.002	0.067	0.099	0.200
% CV	0.100	1.800	2.000	3.100

Means with a common letter in a column are not significantly different (P>0.05).

NGTB = New Guinea Table Birds; SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

Birds fed on the NGTB diet had significantly higher (P<0.001) end weight in the trial compared to birds on the other diets. Birds fed the SP70L diet had the lowest end weight. Birds on the SP50L and CAS50H diets had similar end weights but these were significantly lower than those on the NGTB diet but higher than those on the SP70L diet (Table 11).

Table 12. Weight gain (kg) of birds fed 4 diets; Control vs. concentrate + sweet potato or cassava at LDS.

Experimental diets	Day 28	Day 35	Day 42
NGTB broiler finisher	0.676a	0.535a	0.712a
SP50L	0.518b	0.484b	0.540ab
CAS50H	0.526b	0.533a	0.516ab
SP70L	0.353c	0.301c	0.331b
P-value	<0.001	<0.001	0.043
LSD	0.066	0.037	0.229
% CV	4.600	2.900	15.700

Means with a common letter in a column are not significantly different (P>0.05).

NGTB = New Guinea Table Birds; SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

For the LDS trial the weight gain of birds on day 28 (at LDS) fed the NGTB diet were higher (P<0.001) than birds fed on the other diets. Birds fed the SP50L and CAS50H diets had similar gains but these were significantly higher than those on the SP70L diet. By day 35, birds on the CAS50H and NGTB diets had a higher gain than birds fed the other diets.

At day 42, the birds fed the NGTB diets still showed significantly higher gain compared to birds on the other diets. Despite birds having lower gains on the SP70L diet they appeared to have improved their weekly weight gain relative to the other diets which brought them closer to birds fed the SP50L and CAS50H diets (Table 12).

Table 13. Weekly feed intakes (kg) of birds fed 4 diets; Control vs. concentrate + sweet potato or cassava at LDS.

Experimental diets	Day 28	Day 35	Day 42
NGTB broiler finisher	1.046	1.147	1.440
SP50L	1.217	1.083	1.238
CAS50H	1.104	1.070	1.214
SP70L	0.916	1.016	1.063
P-value	0.825	0.595	0.201
LSD	0.900	0.251	0.387
% CV	30.300	8.400	11.200

Means with a common letter in a column are not significantly different (P>0.05).

NGTB = New Guinea Table Birds; SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

The feed intake was similar for birds on all diets throughout the experimental phase, although birds fed on the SP50L diet had consistently lower intake (Table 13).

Table 14. Weekly FCR of birds fed 4 diets; Control vs. concentrate + sweet potato or cassava at LDS.

Diet	Day 28	Day 35	Day 42
NGTB broiler finisher	1.549	2.144b	2.041b
SP50L	2.379	2.240b	2.298b
CAS50H	2.120	2.012b	2.056b
SP70L	2.606	3.378a	3.670a
P-value	0.554	0.008	0.007
LSD	1.997	0.576	0.678
% CV	33.200	8.500	9.700

Means with a common letter in a column are not significantly different (P>0.05).

NGTB = New Guinea Table Birds; SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

The FCRs of birds at LDS on all the experimental diets did not differ significantly from each other at day 28, but at days 35 and 42, birds on the SP70L diet had significantly higher (P<0.008 and 0.007) FCRs compared to other diets (Table 14).

At the Ok Tedi site the body weights of birds on day 42 for birds fed the NGTB, SP50L and CAS50H diets were similar, but all were significantly higher (P<0.008) than the weight of birds fed on the SP70L diet (Table 15).

Table 15. Weekly body weight (kg) of birds fed 4 diets; Control vs. concentrate + sweet potato or cassava at Ok Tedi.

Experimental diets	Day 21	Day 28	Day 35	Day 42
NGTB broiler finisher	0.870	1.536a	2.181a	2.570a
SP50L	0.878	1.365b	1.916b	2.463a
CAS50H	0.870	1.339b	1.919b	2.457a
SP70L	0.880	1.174c	1.627c	2.010b
P-value	0.598	0.012	<.001	0.008

LSD	0.024	0.149	0.111	0.224
% CV	1.000	4.000	2.100	3.400

Means with a common letter in a column are not significantly different (P>0.05).

NGTB = New Guinea Table Birds; SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

During week 4 at the Ok Tedi site weight gain of birds fed the NGTB diet were significantly higher (P<0.01) than other diets. At day 42, birds fed the SP50L and CAS50H diets had similar weight gain; both these diets resulted in significantly higher (P<0.06) gains compared to birds fed the SP70L and NGTB diets. Birds fed the SP70L diet had significantly lower weight gains throughout the grow out period (Table 15).

Table 16. Weekly weight gain (kg) of birds fed 4 diets; Control vs. concentrate + sweet potato or cassava at Ok Tedi.

Experimental diets	Day 28	Day 35	Day 42
NGTB broiler finisher	0.666a	0.646a	0.388b
SP50L	0.488b	0.580ab	0.547a
CAS50H	0.469b	0.551ab	0.538a
SP70L	0.294c	0.453b	0.383b
P-value	0.010	0.093	0.060
LSD	0.145	0.149	0.147
% CV	10.900	9.600	11.400

Means with a common letter in a column are not significantly different (P>0.05).

NGTB = New Guinea Table Birds; SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

Table 17. Weekly feed intake (kg) per bird fed 4 diets; Control vs. concentrate + sweet potato or cassava at Ok Tedi.

Experimental diets	Day 28	Day 35	Day 42
NGTB broiler finisher	1.006a	0.973	1.075b
SP50L	0.808b	0.992	1.347a
CAS50H	0.809b	0.942	1.171b
SP70L	0.716b	0.990	1.297a
P-value	0.016	0.866	0.007
LSD	0.135	0.187	0.105
% CV	5.800	6.900	3.100

Means with a common letter in a column are not significantly different (P>0.05).

NGTB = New Guinea Table Birds; SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

Weekly feed intake of birds fed the SP70L diets by day 28 did not differ significantly from birds fed on the SP50L and CAS50H diets, but were significantly lower (P<0.05) than birds fed on the NGTB diet (Table 18). The intakes of birds were similar during week 5 for all experimental diets. During week 6 birds fed on the NGTB diet and the CAS50H diets had lower poorer feed intakes than birds fed on both the SP50L and SP70L diets (Table 17).

Table 18. Weekly FCR of birds fed 4 diets; Control vs. concentrate + sweet potato or cassava at Ok Tedi.

Experimental diets	Day 28	Day 35	Day 42
NGTB broiler finisher	1.510b	1.511	2.843
SP50L	1.660ab	1.813	2.462
CAS50H	1.773ab	1.636	2.182
SP70L	2.446a	2.196	3.430
P-value	0.099	0.169	0.169
LSD	0.790	0.695	1.257
% CV	15.400	14.000	16.600

Means with a common letter in a column are not significantly different (P>0.05).

NGTB = New Guinea Table Birds; SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

In the Ok Tedi trial birds fed on the SP70L diet had significantly higher (P<0.099) FCR compared to birds fed the NGTB diet; but these values were not different from birds fed the SP50L and CAS50H diets. At days 35 and 42, birds fed the SP70L diet still had numerically higher FCR values.

The results averaged for all the NGO sites confirmed findings from the on-station grow-out trial conducted at NARI (Labu) that birds fed the 50% sweet potato with 50% low energy concentrate and 50% cassava with 50% high energy concentrate diets were able to reach market weight of 2 kg or more at 42 days of age (Table 18). Birds fed the 70% sweet potato with 30% low energy concentrate did not reach market weight at 42 days at the CLTC and LDS sites; however, at the Ok Tedi site birds were able to reach market weight at 42 days. This may be due to the climate at the Ok Tedi site being more suited to birds and being closer to their thermoneutral zone.

FCR of birds on these test diets were similar to results obtained at Labu and suggest that birds on the 70% sweet potato with 30% low energy concentrate did not initially convert the feed as well as expected when the diets were introduced but there was a improvement in FCR values as birds became accustomed to the high % of SP in diets. FCR values for birds on the 50% sweet potato with 50% low energy concentrate and 50% cassava with 50% high energy concentrate diets indicated the birds were able to convert these feeds efficiently. The results from all three sites both for end weights and FCR values showed a similar trend and have confirmed results obtained from the trial at Labu.

Based on the results at the NGO's sites it was recommend that two feeding options, namely 50% sweet potato with 50% low energy concentrate and 50% cassava with 50% high energy concentrate be tested on farmer sites to examine if birds can reach market weight of 2 kg as shown in the NGO grow out trials.

Table 19. Weekly weight (kg) and FCR of birds fed 4 diets; control vs. concentrate + sweet potato or cassava averaged over the NGO sites

	Weekly weight				Weekly FCR		
Diets	**Day 21**	**Day 28**	**Day 35**	**Day 42**	**Day 28**	**Day 35**	**Day 42**
Control	0.8278a	1.461a	2.060a	2.673a	1.66a	1.76a	2.32a
SP50L	0.8280a	1.296b	1.782b	2.305b	2.19a	2.16a	2.31a
CAS50H	0.8302a	1.320b	1.818b	2.363b	2.04a	1.96a	2.41a
SP70L	0.8300a	1.078c	1.413c	1.770c	5.28b	2.97a	3.63b
P-value	0.749	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
LSD	0.006	0.066	0.096	0.161	2.392	0.472	0.445
CV %	48.0	6.5	8.5	5.1	70.7	17.6	13.7

Means with a common subscript are not significantly different (P > 0.05)

SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

When results were pooled from all sites birds fed on control diets had significantly higher body weight on Day 42, while birds on the SP70L diet had significantly lower body weight (Table 19). Birds fed the SP50L and CAS50H diets were able to reach market weight of 2 kg on day 42

Weekly FCR values of birds fed on the control diets had significantly lower FCR at all three sites. Weekly FCR values of birds fed on the SP70L diet had significantly poorer FCR values at all three sites (Table 19).

Table 20. Weekly intake (kg) of birds fed 4 diets; Control vs. concentrate + sweet potato or cassava averaged over the NGO sites

Diets	Day 28	Day 35	Day 42
Control	1.038a	1.039a	1.340a
SP50L	0.995a	0.993a	1.207a
CAS50H	0.996a	0.969a	1.312a
SP70L	0.881a	0.945b	1.287a
P-value	0.464	0.171	0.355
LSD	0.212	0.087	0.159
CV %	17.9	7.3	10.2

Means with a common subscript are not significantly different (P > 0.05)

SP50L = Sweet potato + 50% LEC; CAS50H = Cassava + 50% HEC; SP70L = Sweet potato + 50% LEC; CAS70H = Cassava + 70% HEC.

Birds on all diets at all sites had feed intakes that were not significantly different at weeks 4 & 6. At week 5, birds on 70SP/ 30LEC diets at all sites had significantly lower intakes (Table 20).

Wet mash feeding

Results of grow-out trials at NGO sites confirmed the results obtained at Labu. Birds fed 70% SP + 30% LEC required an additional week to reach market weight of 2 kg. Cassava with high energy concentrate is recommended for Lowlands. Sweet potato with low energy concentrate is recommended for the Highlands.

The form in which sweet potato and cassava is fed to broilers required investigation as milling sweet potato and cassava flour may be too tedious for farmers to undertake. Hence, performance of broilers fed dry and boiled sweet potato was investigated.

Farmers are more likely to use the boiled sweet potato tuber by mashing it and mixing it with the concentrate. It is not clear if bird growth is affected by form of presentation of the sweet potato component.

The treatments tested on-station at NARI were; milled sweet potato (50%); mashed sweet potato (50%); milled sweet potato (70%); mashed sweet potato (70%) all fed with a low energy concentrate vs. control (standard commercial finisher).

The experimental design comprised treatments; 2 blocks (sides of a shed); 2 replicates per block; 12 birds per pen.

For three weeks birds were on the starter phase and then on the grow-out phase for 4 weeks.

Table 21. Weekly feed intake (kg - DM basis for birds) for mashed vs. dried sweet potato fed with low energy concentrate.

Weeks in feeding	Wk 4	Wk 5	Wk 6	Wk 7
P Value	0.875	<0.001	<0.001	<0.001
Overall Mean	9.577	12.12	14.3	14.27
Milled 50% LEC	9.57	13.84b	16.97c	15.28b
Mashed 50% LEC	9.505	11.31a	13.34a	17.69c
Milled 70% LEC	9.515	11.54a	13.55a	11.84a
Mashed 70% LEC	9.678	10.51a	12.71a	15.63b
Standard broiler grower	9.617	13.41b	14.92b	10.92a
LSD 5%	0.401	0.865	1.266	1.129
CV %	2.8	4.7	5.8	5.2

Means with a common subscript are not significantly different (P > 0.05). LEC= Low Energy Concentrate

Table 22. Body weight (kg) for birds fed mashed vs. dried sweet potato fed with low energy concentrate.

Weeks in feeding	Wk 4	Wk 5	Wk 6	Wk 7
P Value	0.22	<0.001	<0.001	<0.001
Overall Mean	1.245	1.577	2.029	2.451
Milled 50% LEC	1.25	1.611b	2.108b	2.539c
Mashed 50% LEC	1.245	1.565b	2.082b	2.631c
Milled 70% LEC	1.239	1.44a	1.766a	2.081a
Mashed 70% LEC	1.251	1.462a	1.822a	2.229b
Standard broiler grower	1.238	1.806c	2.365c	2.772d
LSD 5%	0.014	0.078	0.125	0.133
CV %	0.8	3.3	4	3.6

Means with a common subscript are not significantly different (P > 0.05). LEC= Low Energy Concentrate

Table 23. FCR (DM basis) of birds fed mashed vs. dried sweet potato fed with low energy concentrate.

Weeks in feeding	Wk 4	Wk 5	Wk 6	Wk 7
P Value	0.2	<0.001	<0.001	0.911
Overall Mean	1.896	3.46	2.84	3.32
Milled 50% LEC	1.855	3.19b	2.853b	2.99
Mashed 50% LEC	1.905	3.0b	2.247c	3.23
Milled 70% LEC	1.939	4.88a	3.474a	3.14
Mashed 70% LEC	1.851	4.21a	2.946b	3.68
Standard broiler grower	1.931	2.01c	2.681b	3.58
LSD 5%	0.096	0.7	0.399	1.816
CV %	3.3	13.3	9.3	36

Means with a common subscript are not significantly different (P > 0.05). LEC= Low Energy Concentrate

The body weight of birds fed control vs. milled vs. wet mash diets showed significant differences from week 5, with the standard finisher diet performing the best as expected, followed by the 50% milled and mashed formulations (Table 21).

Weekly weights were similar for the 50% mashed and 50% milled diets. The same was true for 70% mashed and 70% milled during week 5 and week 6, but not during week 7 (Table 22). During week 5 birds fed the standard finisher had a better FCR followed by the 50% mashed and then 50% milled. Both of the 70% formulations performed poorly. During week 6 the 50% mashed formulation has superior FCR than the other diets, even better than the standard and 50% milled. Overall, growth performance of birds is similar when fed the SP mashed and milled formulations. Birds were fed *ad libitum* but the mashed formulation had to be processed twice a day to avoid spoilage and spillage. Under these circumstances, the high moisture content of mashed diets did not affect average intake and FCR.

Both milled and mashed formulations can be promoted – milled formulation through mini mills and the mashed formulation by individual farmers running smallholder operations. More importantly farmers will not lose out in terms of growth and FCR when they use mashed formulations. It is clear that growth performance of birds is not be affected by form (mashed or milled) of presentation of sweet potato component of the diet.

The SP50L diet is a very convenient diet to feed since 1 bag of concentrate can replace 3 bags of commercial finisher during the finishing phase and sweet potato is readily available. The cost of transporting stock feed will be minimized from the current freight rate of K10 per bag into this remote area. There is no significant difference between the two diet groups when comparing body size. It was reported that the taste of meat from the diet groups were different. The meat from birds fed the SP50L diet had better taste than meat from birds fed the finisher diet. SP potato is a staple for breakfast and dinner in village diets. Since SP can be fed to birds it is also easier to prepare both SP for the family and to feed the chickens at the same time.

8.1.6 To develop on-station a range of best-bet feeding options for indigenous poultry, imported hybrid layers and Australorps (project extension)

The sweet potato diet (HELC+SP) and the cassava diet (LELC+C) were tested with laying hens using the NARI poultry facilities. The performance of a commercial hybrid, village chickens and an Australorp x commercial hybrid cross was evaluated over the peak egg production period (26-36 weeks). Hens fed on LELC + C diet produced more eggs than birds fed the HELC + SP diet and the commercial layer diet (Figure 1). The Australorp cross had the highest egg production throughout the trial compared to the commercial strain (Figure 1); the village strain had the lowest egg production. The commercial strain was expected to achieve the highest egg production. However, high levels of cannibalism and feather pecking noted in the commercial strain resulted in 28% mortality while the Australorp cross and village hens had 7% mortality. This finding indicates that commercial layers have a high propensity for cannibalism compared to locally bred strains and beak trimming should be used to avert the pecking problem.

Figure 1. Egg production performance of genotype and birds fed HELC+SP, LELC +C compared to a commercial layer diet.

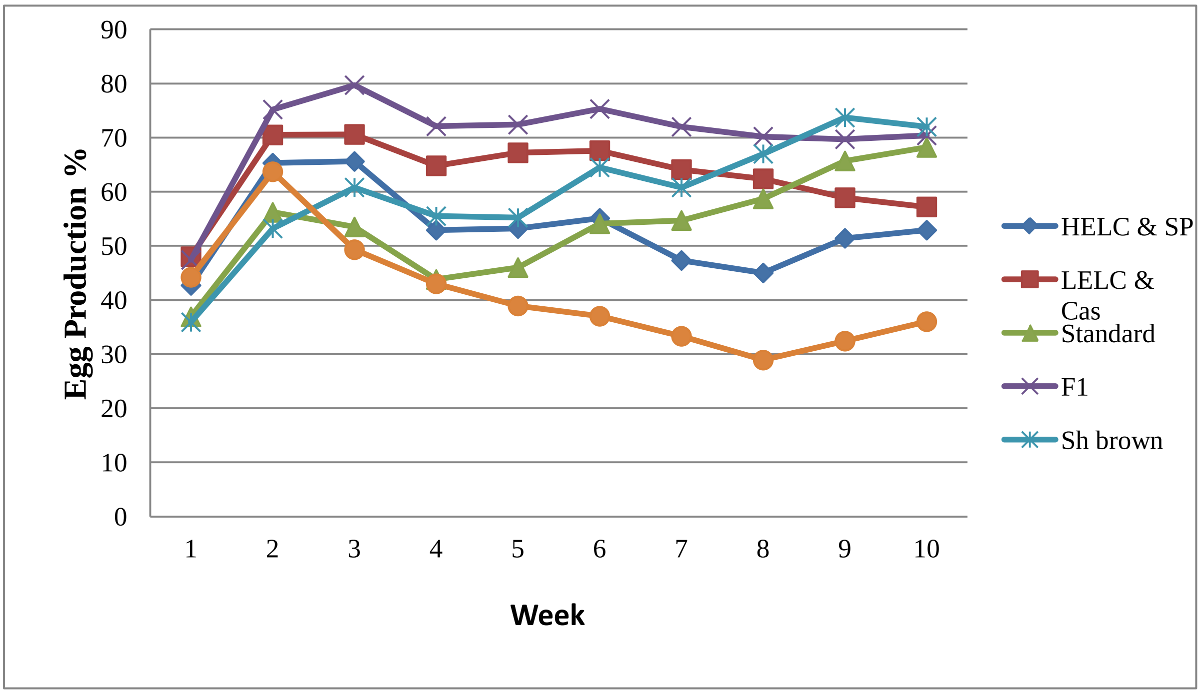


Table 24. Overall egg production percentage by genotype and diet; HELC+SP and LELC +C compared to a commercial layer diet.

Treatment	Egg Production (%)
Village	38.1c
Australorp cross	70.4e
Hyline Brown	52.6a
HELC+SP	52.7a
LELC+Cass	61.9d
Comm	46.5b
Grand mean	53.7
P-value	<.001

Means followed by a common letter are not significantly different (P>0.05).

Table 25. Mortality of birds in NARI on-station trial according to genotype and diet; HELC+SP and LELC +C compared to a commercial layer diet.

Treatments	Mortality%
HELC+SP	2.04
LELC+Cass	7.14
Hyline Brown	26.18
Aust Cross	4.76
Hyline Brown	25.86
Village	4.76
Grand mean	NA
P-value	NA

The Australorp crosses had the highest feed intake (128.9 g/day) on a dry matter basis compared to village hens at 92.6 g/day with the commercial hybrid consuming 122.5 g/day (Table 26). The birds fed the LELC + C diet consumed 129.9 g/day which was significantly different (P<.001) from birds fed the HELC + SP diet (111.4 g/hen/day) and the commercial diet (96.7 g/hen/day).

Table 26. Feed intake, egg weight and FCR of genotypes and diets; HELC+SP and LELC +C compared to a commercial layer diet.

Genotype	Feed Intake (g/bird/day-dm basis)	Average egg weight (g)	FCR (Kg eggs/kg feed)
Commercial	122.5 a	57.85 a	2.128 a
Australorp Cross	128.9 a	55.89 b	2.314 b
Village	92.6 b	50.2 c	1.846 c
P-value	<.001	<.001	<.001
Diet			
Commercial	96.7 a	56.1 a	1.715 a
HELC & SP	111.4 b	54.3 b	2.154 b
LELC & C	129.9 c	53.5 b	2.419 c
Grand mean	114.7	54.65	2.096
P-value	<.001	<.001	<.001
SEM	2.942	0.475	0.0515
LSD 5%	8.162	0.933	0.1428
CV%	30.4	7.3	29.1
Min	7.591	40	0.138
Max	521.9	92.5	4.903
Value	1260	1260	1260

Means with a common letter within a column are not statistically different (P>0.05).

As expected the commercial layers had the highest egg weight (57.9 g) compared to the Australorp cross (55.9 g) with village hen having the lowest weight (50.2 g). Similarly, chickens fed on the standard diet (as expected) achieved the highest egg weight (56.1 g) compared to birds fed on HELC + SP and LELC + C formulation; 54.3 and 53.5 g respectively (Table 26).

The most efficient converter of feed (FCR) was the village chicken followed by the commercial hybrid and the Australorp. When feed type is considered birds fed on the standard diet had significantly better FCR than birds fed on the HELC + SP and LELC + SP (Table 26).

The body weight of hens was significantly (P<0.05) different between the genotypes: Australorp crosses had the highest body weight (1.79 kg), followed by the Hyline Brown (1.62kg) and the Village hens (1.5kg). The Hyline Brown hen weight is line with the range 1.5 to 1.94 kg given in the guideline for the breed (Hy-line Brown International, 2008).

On the other hand, body weight did not vary between the diets; with birds fed the HELC+SP showing a slightly higher weight (Table 27). The weight gain of hens during the trial did not vary between genotype or diet.

Table 27. Average body weight and weight gain of hens by genotype and diet (HELC+SP and LELC +C compared to a commercial layer diet).

Treatments	Body weight (kg)	Weight gain/hen (g)
Village	1.497a	10a
Australorp	1.790b	45a
Hyline Brown	1.620c	40a
P-value	<.001	0.356
HELC+SP	1.672a	56a
LELC+C	1.625ab	3b
Hyline Brown	1.612b	36ab
P-Value	0.066	0.141
Grand mean	1.636	31
LSD 5%	0.0523	52.9

Means followed by a common letter are not significantly different (P>0.05)

The feed cost (**HELC+SP, LELC +C, commercial layer diet)** for egg production was derived from calculated values of daily feed intake, cost of rations and the FCR (Table 26). Combining DM feed intake with FCR gives egg weight equivalent of feed intake of 56.9g per day for commercial feed, 53.0g for HELC+SP and 54.1g for LELC+C. Relating these to the average cost of diets gives an estimate of daily feed cost of egg production for each diet: PGK0.15 for commercial, PGK0.093 for HELC+SP and PGK0.084 for LELC+C. The values were corrected for the differences in the proxy indicator of average egg weight to give the feed cost of 53g eggs of PGK0.14 for commercial, PGK0.093 for LELC-SP and PGK0.082 for LELC+C (Table 28). On that basis it can be inferred that the overall feed cost of egg production using HELC+SP and HELC+C was reduced to 66.4% and 58.6% from that of the control commercial layer pellet.

Table 28. Egg weight equivalent of feed intake and feed cost of eggs for diets; HELC+SP and LELC +C compared to a commercial layer diet.

Diets	DM feed intake per day (g)	Cost/kg DM feed (PGK)	Cost of daily DM feed consumed (PGK)	FCR	Egg weight equiv. of daily feed intake (g)	Daily feed cost of egg (PGK)	Feed cost of 53g egg (PGK)
Commercial	96.7	2.64	0.255	1.7	56.9	0.150	0.140
HELC+SP	111.4	1.75	0.195	2.1	53.0	0.093	0.093
LELC+Cass	129.9	1.55	0.201	2.4	54.1	0.084	0.082

The result confirmed that using preferred locally produced sweet potato and cassava as major sources of energy in layer diets will result in reduced cost of feeding the birds, despite poorer FCR and higher DM intake values.

It is clear that the three genotypes adapted well to the sweet potato and cassava based test layer diets, and they maintained similarly high overall egg production levels by increasing their feed intake. Mortality of Australorp crosses and village hens fed the HELC+SP and LELC+C diet were also lower compared to the commercial hybrid fed the commercial layer diet. In particular it is surprising that village hens maintained good performance levels close to that of the modern hybrids when fed the lower cost feeding options. Given the dietary effects noted for genotype on egg production performance and mortality, the best bet option to recommend to village poultry producers is to use an Australorp cross and feed them with HELC+SP and LELC+C. The village chickens fed commercial layer pellets and/or HELC+SP had high feed conversion efficiency. The results indicate that Australorp crossbred and village hens can be used for egg production when fed on LELC+C and HELC+SP diets. It was therefore recommended that these lower cost feeding options be further tested at NGO test facilities as well as on-farm in areas where interest on egg production is high. Moreover, evidence from this study indicates that use of locally grown sweet potato and cassava in layer diets for Australorp and village hens is likely to be worthwhile for local poultry producers and be promoted in PNG. This finding is important because 40% of the bulk of these diets is made up of local feed plus the genotypes used can be acquired locally. Therefore the feeding and production system is sustainable in terms of cost, disease resistance and survival of genotypes under local environmental conditions.

8.2 Objective 2: To evaluate broiler production and profitability on-farm of various feeding options that incorporate local feeds

8.2.1 Train extension staff

Standard operating procedures were documented for the conduct and monitoring of on-farm activities. CLTC, LDS, Ok Tedi and SA staff were trained in the conduct and monitoring of on-farm evaluation studies.

Significant capacity building occurred during the project. During the village trials the farmers worked closely with NARI and the NGO's to validate and demonstrate the broiler feeding system. This activity involved training in the methodology required to operate a field trial and capacity building of the farmers during the visits made by NGO and NARI staff. A number of trained farmers have supported other farmers to run trials not officially involved in the project.

8.2.2 Establish demonstration trials with farmers

On-farm demonstration sites were selected by CLTC and SA in highlands, LDS in lowlands and Ok Tedi in the Western Province.

Two highland village farm sites were selected to feed broilers on SP plus concentrate associated with CLTC and the SA. Two lowland village farm sites were selected to feed broilers on Cassava plus concentrate at LDS and OTML. One box of sexed DOC were provided to each farmer and divided into two groups; one half of the chickens were fed the test diet and the other half the control diet (commercial finisher).

Table 29. Body weight of broilers fed SP50L on 10 village farms (associated with CLTC) in the highlands.

	Diets	Mean (Kg)	min	max	t-value	P-value
Week 4	SP50L	1.507	1.338	1.696	0.53	0.606
	Control	1.514	1.331	1.767		
Week 5	SP50L	2.172	1.936	2.333	1.88	0.093
	Control	2.301	2.072	2.600		
Week 6	SP50L	2.7338	2.467	3.109	1.77	0.111
	Control	2.512	2.922	3.242		

The village trials were held with 10 village farmers using the LEC (1 kg LEC mix with 3 kg mashed SP) compared with the control NGTB broiler finisher.

All the farmers were interested in this project and followed all the protocols and procedures. They had an abundant supply of sweet potatoes. The project ran smoothly. The birds fed with SP50L had fewer deaths during the change over phase from starter to finisher. There was a taste preference for meat from birds fed the SP50L and the body weight of birds fed the SP50L diet was higher at week 6 than the control birds (Table 29 and 30). Farmers requested that the LEC be provided to the market as soon as possible. They were keen to adopt the technology. General observation on farmer's reactions and approach in the village trials were positive. There is an excess of sweet potato in the villages which sometimes is spoiled or damaged by rats due to a lack of proper storage facilities, distance from the market and transport costs. The feeding method of using SP and concentrate can boost the economy and provide major savings in the village. The farmers are very happy with this technology as they believe it will increase their profit.

Table 30. Body weight of broilers fed SP50L on 9 village farms (associated with Salvation Army) in the highlands.

	Diets	Mean (Kg)	min	max	t-value	P-value
Week 4	SP50L	1.277	1.115	1.425	2.27	0.053
	Control	1.303	1.132	1.530		
Week 5	SP50L	1.661	1.180	2.000	1.45	0.184
	Control	1.792	1.326	2.526		
Week 6	SP50L	2.395	1.979	2.711	0.25	0.827
	Control	2.422	2.184	2.676		

Table 31. Body weight of broilers fed C50H on 10 village farms (associated with LDS) in the lowlands.

	Diets	Mean (Kg)	min	max	t-value	P-value
Week 4	C50H	1.133	0.692	1.556	0.63	0.542
	Control	1.137	0.700	1.546		
Week 5	C50H	1.512	1.000	2.040	2.03	0.077
	Control	1.630	0.985	2.100		
Week 6	C50H	1.703	1.205	2.304	2.53	0.32
	Control	1.967	0.954	2.680		

The target group at the LDS village sites were resource-poor people and communities in the most remote areas of the PNG lowlands. Motivators and their families in rural and remote communities improve their standard of living through sustainable agriculture practices.

Observations made by LDS Fisika staff indicated that the feeding system reduced expenditure for broiler farmers and increased profit for the broiler enterprise. The body weight of birds on the cassava based diet were equivalent to bird fed the commercial diet (Table 31).There was an increased demand for lower priced broilers and a preference of consumers for broilers fed with concentrate and cassava. Up to 75% of participants in trials want to continue their activities with concentrate/ cassava. There were no complaints about the increased labour associated with the feeding system. The concentrate cassava mixture was well received by broiler farmers and there was a strong interest from other broiler farmers not involved with the trials. Some farmers expressed an interest to use other alternatives with resources which are also available in the coastal region (coconuts, sweet potato and taro).

LDS have continued to work with trial farmers and with additional villagers in the Finschhafen District and Madang Province to promote the feeding regime. LDS Fisika in cooperation with local business (A. Sifuyu Ltd) currently buys and stocks the concentrate so it is readily available for interested farmers. LDS Fisika has extended the promotion and training support to other areas. The concentrate is available in sufficient quantities at a competitive price.

Table 32. Body weight of broilers fed C50H on 12 village farms (associated with OTML) in the Western Province.

	Diets	Mean	min	max	t-value	P-value
Week 4	Cassava	1.385	1.047	1.724	0.84	0.420
	Control	1.400	1.043	1.736		
Week 5	Cassava	1.822	1.330	2.294	2.66	0.022
	Control	2.014	1.755	2.283		
Week 6	Cassava	2.284	1.460	2.997	3.17	0.009
	Control	2.563	2.003	3.020		

The trials at OTML involved 12 farmers at Kiunga, Star Mountains and Tabubil. Two farmers used the 50SPL concentrate while the others used CAS50H. The performance data were collected on a weekly basis (Table 32). Farmers were trained in basic broiler husbandry and feed mixing before the start of the experimental phase. Farmer trials were conducted in semi-permanent and bush material poultry houses established by each of the12 farmers in the North Fly Region. The trial consisted of 3 test diets (CAS50L and SP50L) and the NGTB broiler finisher diet with 1 replicate of each of these diets. A total of 12 boxes of day old chicks were distributed equally to the 12 farmers; each farmer having equal numbers of males and females. From day 1 - 28, the broiler chickens were fed with NGTB starter crumble feed. The birds were equally distributed into two pens based on their weights. Experimental diets were introduced on day 28 up until day 42 when the trial was terminated. There were a number of issues that impacted on the trial results including inconsistent use of scales during data collection and lack of uniformity in the conduct of the experiment from farmer to farmer. Some farmers did not comply with the instructions and spillage was noted when they used inappropriate feeding and drinking utensils. Farmers indicated the technology is appropriate and most suitable to boost village broiler production in the Western Province. The feeding method provides a reduction in the cost of feeding chickens compared with feeding commercial finisher diets despite the lower body weight achieved with the cassava based diet. However the profit was improved thus creating an economic opportunity for farmers to save money and meet their needs. Chickens reached market weight within 42 days and provide an opportunity for establishing sustainable poultry businesses in the Western Province.

The overall performance of broilers at each of the sites on the test diets was very good with birds attaining target market of over 2 kg from week 5. The sweet potato based diets compare very well with the commercial control based on market weight. No problems were reported by farmers with preparation of the mashed diets twice every day.

8.2.3 Objective 3: To evaluate layer production and profitability on-farm of various feeding options that incorporate local feeds (project extension)

To evaluate the performance of laying hens birds fed the SP and cassava diets, trials with commercial hybrids and village chickens were conducted at NGO partner sites (CLTC in the highlands and LDS in the lowlands). At CLTC, commercial hybrids and Australorp crosses (in separate experiments) were fed 3 treatments diets from 25-37 weeks of age for the hybrids and 26-34 weeks for the Australorp crosses. The diets were; 1)

Commercial layer diet, 2) HELC + SP and 3) LELC + C while at the LDS site village chickens were fed the same treatment diets from 25-37 weeks of age.

At the CLTC site egg production in the first trial with the commercial hybrids was significantly (P<0.05) lower in birds fed the HELC +SP and LELC + C ration compared to the commercial ration (Figure 2).

Fig 2: Egg production % of commercial hybrid at CLTC on-farm trial fed the commercial layer crumbles vs. 2 test diets (HELC+SP and LELC + C) from 25-37 weeks.

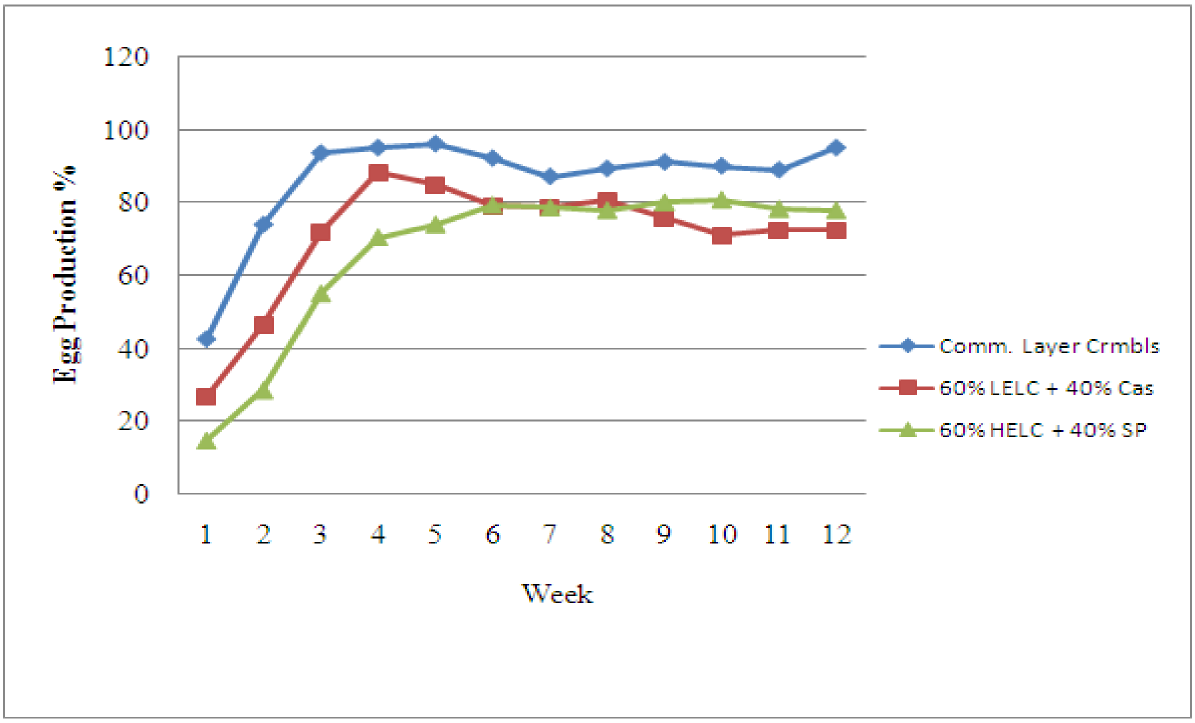


Table 33: Hen house production, egg weight, feed intake (dm basis,) FCR at CLTC site for commercial hybrids fed with a commercial layer ration and two test diets (HELC+SP and LELC + C) from 25-37 weeks.

	Hen House Production	Egg Weight (g)	Feed Intake (g) DM basis	FCR Kg feed/Kg egg
P-value	<.001	<.001	<.001	<.001
Standard	0.862 c	56.6 a	123.5 b	2.172 b
HELC & SP	0.663 b	55.82 a	94.8 a	1.698 c
LELC & Cas	0.707 a	52.28 b	101.8 a	1.952 a
Grand Mean	0.744	54.9	106.7	1.941
SEM	0.0115	0.338	3.33	0.057
LSD 5%	0.032	0.939	9.31	0.159
CV%	28.4	11.3	21.6	0.1594
Min	0.1	18.57	57.46	1.094
Max	1.1	98.75	178.4	3.146
Value	1008	1008	144	144

Means with a common letter within a column are not statistically different (P>0.05).

The hens fed the commercial ration had the highest egg production (86%) followed by 71% for hens fed the LELC + C diet. The poorest production (66%) was for hens fed the HELC + SP diet (Table 33). The highest egg weight was achieved by hens fed on the commercial ration (56.6 g) although it was not significantly different (P>0.05) from birds fed the HELC + SP diet (55.8 g). However the egg weight of hens fed on HELC + C diet (52.3g) was significantly (P<0.05) lower than the other treatments.

The feed intake of hybrids fed the commercial ration (123.5g/day) was significantly higher (P<.001) than the feed intake of birds on the other diets. Hens fed the LELC + C formulation consumed 101.8g/day which was similar (P>0.05) to the feed intake (94.8g) of birds fed the HELC + SP formulation (Table 33). There was a significant difference (P<0.05) between all diets in FCR. Hens fed the HELC + SP diet had a superior FCR (1.69) than birds fed the LELC + C diet (1.95) and the commercial ration (2.17).

The body weight of birds fed the HELC + SP diet (2.01kg) was similar to birds fed the LELC + C diet (Table 34) but the bodyweight of hens fed the local diets differed significantly (P<0.05) from the birds fed the commercial ration (1.94 kg).

Table 34. Body weight of the commercial hybrid hens fed the commercial layer ration, the HELC + SP and the LELC + C ration over 25-37 weeks at CLTC.

Treatment	Body weight (kg)
Commercial layer diet	1.94b
60% HELC +40% SP	2.01a
60% HELC + 40% C	1.99a
P value	<.001

Means with a different letter within a column are statistically different (P<0.05).

At CLTC the commercial hybrids fed the 3 diets from 25-37 weeks demonstrated highly significant differences in egg production %, egg weight, feed intake, FCR and body weight (Table 34). The birds fed the cassava and sweet potato based rations had lower feed intakes relative to the control birds and they produced fewer eggs and lower egg weight. This suggests that it may have been difficult for birds to consume sufficient nutrients to support their egg production potential. The high moisture content in the cassava and sweet potato based diets may have resulted in the birds achieving crop fill and satiety limiting their ability to consume further feed and obtaining the required nutrients to support full egg production. The results suggest that a change in the formulation is required to make the concentrate diet more energy and protein rich, particularly given the diets had high moisture content. On the other hand it is clear that birds consuming the tuber based diets had a superior feed conversion efficiency. The high moisture content in the tuber diets may have led to nutrients in the diet becoming more readily available in the gut. It is likely that cooking solubilised more of the nutrients in the tubers making them more readily available for digestion and absorption in the gut. In addition the high moisture content of the tuber diets in the gut may have lead to greater digestion and absorption per se.

For the CLTC trial body weight of Australorp crossbred hens at the start and end of the experiment were not significantly different (P>0.05) despite being fed different diets (Table 36). The layers on the standard layer ration had higher egg production compared to those on the concentrate diets, however these differences were not significant at P>0.05. The same trend was observed in hen house production over the experiment. Layers on the standard ration laid a total of 37 eggs followed by birds fed the high and low energy concentrate diets with 31 eggs respectively (Table 36).

Table 35. Experimental diet specifications in layer trial conducted at CLTC

Diet	ME (MJ/Kg)	Crude Protein (%)	Crude Fat (%)	Crude Fibre (%)	Calcium %	Phosphorus (available) %
LELC + Cas	11.63	14.57	5.66	4.69	2.76	0.48
HELC + SP	12.83	15.47	6.06	2.14	2.73	0.47
Standard	11.0	16.0	4.0	3.0	3.0	0.41
Standard Diet Requirements	11.2	16.0	3.0	3.0	3.6	0.55

Table 36. Body weight and egg production of Australorp crossbred layers at the CLTC site fed a commercial layer diet compared to LELC+C and HELC+SP from 25-33 weeks

Diet	Body weight (25 weeks)	Body weight (33 weeks)	No. of eggs laid (trial period)	Hen House Egg Production
Standard	1.49a	1.60a	183.5a	66a
LELC + C	1.67a	1.68a	156.5a	56a
HELC + SP	1.65a	1.77a	153.5a	55a
Grand mean	1.60	1.68	164.5	59
P-Value	0.211	0.588	0.357	0.357
SEM	0.059	0.107	13.57	2.71
CV %	5.3	9	11.7	11.7

Means in a column with a common letter are not significantly different at P>0.05

Table 37. Feed intake, egg mass and FCR of Australorp crossbred layers at CLTC fed a commercial layer diet compared to LELC+C and HELC+SP from 25-33 weeks

Diet	Feed intake (g/hen/day)	Egg mass (g/hen/day)	Egg weight (g)	FCR (Kg feed/kg eggs)
Standard	105.4a	36.2	55.3a	1.91a
LELC + C	125.2b	28.8	51.8a	2.43b
HELC + SP	133.0c	29.1	53.0a	2.51b
Grand mean	121.2	31.4	53.3	2.28
P-Value	<.001	0.246	0.546	0.036
SEM	1.07	2.76	2.1	0.094
CV %	1.2	12.6	5.6	5.8

Means in columns with the same letter are not significantly different at P>0.05

Feed intake of Australorp layers fed the standard ration was significantly (P< 0.05) lower (105g) than the concentrate diets (Table 37) indicating birds fed the concentrate diets need to consume more feed to meet their nutrient requirement. Layers on the standard ration had significantly higher egg weight and better FCR compared to birds fed the concentrate diets (Table 37) reflecting the lower protein and calcium content of the concentrate diets (Table 35).

Table 38. Cost of egg production (Kina) at the CLTC site based on feed provided to Australorp crossbred layers pullets fed a commercial layer diet compared to LELC+C and HELC+SP from 25-33 weeks.

Diet	Feed cost (hen/day)	Cost /dozen eggs
Standard	0.25a	3.87a
LELC + C	0.25a	3.27a
HELC + SP	0.27b	3.4a
Grand mean	0.25	3.51
P-Value	0.04	0.44
SEM	0.003	0.303
CV %	1.4	12.2

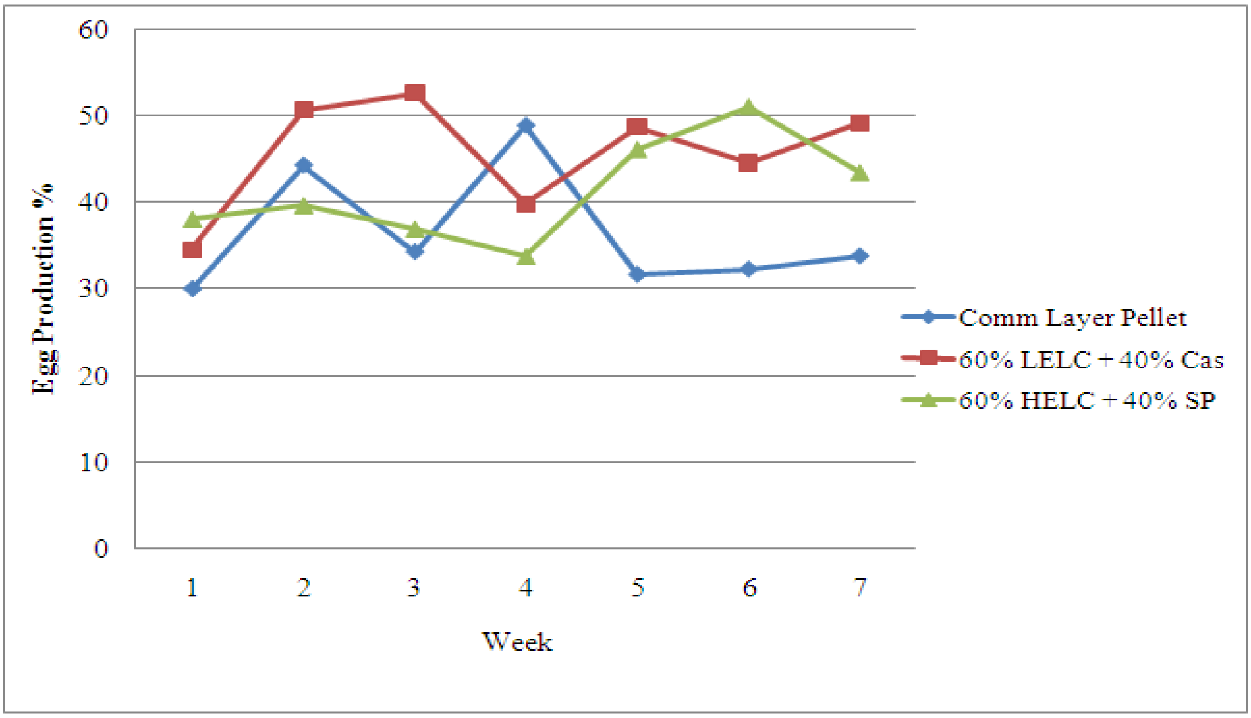
Means in columns with the same letter are not significantly different at P>0.05

Table 38 shows the feed costs and excludes layer costs and other fixed costs. The feed cost on a hen per day basis was cheaper for the standard layer diet and cassava based diet relative to the sweet potato based diet. The cost per dozen eggs was lower for the birds fed on both concentrate diets although this was not significant (Table 38).

When the results of the feeding trial with the Australorp crosses are assessed on the basis of egg prodcution and feed costs the use of the concnetrate diet to feed to layers is promising. A layer type concentrate for egg laying genotypes such as the F1 crossbred layers and village chickens which can be bulked with cassava or sweet potato is considered to be a cheaper alternative for farmers wanting to venture into small-scale table egg enterprises. Some farmers have a surplus of cassava and sweet potato which makes it economical to feed to layers with a protein concentrate. The on site layer trial with Australorp crosses did not confirm results obtained from the on station trial which showed the Australorp crosses performed better in terms of egg production when fed on the HELC + C diets. Layers fed the standard layer ration produced more eggs, higher FCRs and lower production costs as was expected. Layers fed on the LELC + C had the second highest egg production and FCR. This trend is similar to the on station trial and the on-site Hyline layer trial where pullets on this concentrate performed better than those pullets on the HELC + SP diets.

The results from the trial in terms of cost are rather high compared to feeding layer genotypes the commercial egg layer ration. However it must be noted that the trials both on station and on-site ran for only eight weeks. Given higher input costs associated with the running intensive commercial layer enterprises it could be cheaper in the long term to utilize the layer concentrate feeding systems with Australorp crosses and village chickens for semi-commercial or extensive table egg producers.

Fig 3: Egg Production % of village hens at LDS Experiment fed on commercial layer pellet vs. two test diets



At the LDS site in the lowlands, village hens were fed 3 diets from 25-32 weeks of age ; 1) Commercial layer diet, 2) HELC + SP and 3) LELC + C. Village hens fed the LELC + C diet produced more eggs (46.6%) than birds fed HELC +SP (41.1%) and the commercial layer diet (37.1%). The production curve (Fig 3) shows week to week fluctuation in rate of lay for all treatment groups. Village hens tend to lay eggs in a series of small clutches which usually accounts for the weekly fluctuation in egg production. In addition the low number of replicates and bird numbers used in the trial could account for the large variation observed when data is plotted on a weekly basis. Nevertheless the village birds fed the sweet potato and cassava based diets had a relatively good rate of lay relative to the control diet with birds on the cassava diet laying the most eggs.

The egg weight was similar (P>0.05) for village birds fed the commercial layer diet and the sweet potato based diet (Table 39) but surprisingly the egg weight of the birds fed the cassava based diet was about 4 g lighter despite having a higher feed intake (123g/bird) than the control ration (73g/bird) and the sweet potato diet (117g.bird). The lower feed intake of the birds fed the commercial layer ration resulted in a better FCR (1.4) than the two test diets (Table 39).

Table 39. Egg production, egg weight, feed intake and FCR of village hens at the LDS site fed the commercial layer ration, the HELC + SP and the LELC + C ration from 25-37 weeks.

Diet	Hen House Production (eggs/week)	Egg Weight (g)	Feed Intake (g/bird/day) dm basis	FCR (kg feed/kg eggs)	FCR (kg feed/dozen eggs)
Standard	0.371 a	50.94 a	72.9 b	1.443 c	2.425 b
HELC + SP	0.413 ab	51.34 a	116.8 a	2.281 a	3.443 a
LELC + C	0.466 b	46.77 c	123 a	2.642 b	3.324 a
Grand Mean	0.417	49.68	104.2	2.122	3.064
P-value	0.025	<.001	<.001	<.001	<.001
SEM	0.0242	0.479	4.82	0.104	0.1413
LSD 5%	0.0683	1.354	13.62	0.2942	0.3996
CV%	28.4	4.7	22.6	24	22.6
Min	0.2	41.7	56.18	1.018	1.53
Max	0.7	57.2	164.3	3.497	5.564
Value	72	72	72	72	72

Means with a common letter within a column are not statistically different (P>0.05).

The village hens fed the LELC + C diet had the highest egg production % compared to birds fed on the commercial ration while birds fed the HELC + SP diet were intermediate in their rate of lay relative to the other diets. The results in this trial were opposite to that found in of the CLTC trial where hens fed on commercial ration had superior performance. These findings implicate differences between genotypes and adaptation to environment conditions. Village hens are smaller birds, less efficient and nutrient requirements are much lower than required by modern hybrids. The results suggest indigenous layer type chicken can perform to their potential when fed sweet potato and cassava based diets. Nevertheless further work is required to refine the formulation of diets, examine feed particle selection by birds from the diet and undertake digestibility trials to resolve some of the questions that have arisen from the current work. The test diets have proven to be a suitable option to develop further in order to reduce cost of feeding given that commercial layer concentrates are the most costly option.

For the on farm trial with the first 4 farmers at Madang actual feed intake was not calculated due to incomplete and unreliable data on feed refusals and spillage/wastage. Average feed offered per bird was calculated from the recorded daily allocations of feed as well as the total amount of experimental feed used during the trial period. On that basis the calculated average feed offered was higher than the expected average DM feed intake (Table 40). However, the calculated average feed offered on a DM basis for the birds fed the test diet (LELC+Cass) was higher than that for the standard commercial control diet over both months. This average slightly increased in the second month for both diets.

The egg weight produced by birds fed the LELC+C diet was higher than the control diet for the first 4 farmers although the egg weight of the birds fed the standard diet ration improved in the second month. The FCR for birds fed the control diet was superior to that of birds on the test diet (LELC+C). This was due to the higher feed intake and higher egg production of birds on the test diet. The rate of lay of eggs was 50.4% and 38.7% for birds on the test and control diets respectively during the first month but this increased to 66.7% and 62.5% respectively in the second month (Table 40).

Table 40. Comparison of the village egg production performance of birds by month on LELC + cassava versus a standard layer ration for the first group of four farmers at Madang

Treatments		Feed intake (DM basis) (gm/bird/day)		Egg weight (gm/bird/day)		FCR (kg feed/kg egg)		Rate of lay (%)	
		Month 1	Month 2	Month 1	Month 2	Month 1	Month 2	Month 1	Month 2
	LELC+C	111.1	112	41.97	45.84	2.006	2.383	50.4	66.8
	Control	98.2	99	36.64	44.75	1.761	2.206	38.7	62.5

For the second group of three farmers in Madang the feed intake and egg production of the birds showed that the calculated feed offered to birds fed the LELC+C ration was higher than birds fed the control diet when assessed on a dry matter basis. Feed intake for both diets increased slightly in the second month. Egg weight of birds was higher for birds fed the standard ration in both months with the egg weight of birds fed the LELC+C approaching the weight of eggs for birds fed the standard diet. FCR of birds fed the control diet was superior throughout the trial. The rate of lay of eggs for birds fed the control diet was higher than birds fed the LELC+C diet over both months, with an increase in the second month for both months (Table 41).

Table 41. Comparison of the village hen egg production performance of birds by month on LELC + C ration versus a standard layer ration for the second group of three farmers at Madang

Treatments		Feed offered (DM basis) (gm/bird/day)		Egg weight (gm/bird/day)		FCR (feed/egg)		Rate of lay (%)	
		Month 1	Month 2	Month 1	Month 2	Month 1	Month 2	Month 1	Month 2
	LELC+C	110.8	112.0	42.6	45.0	2.292	2.187	48.5	48.5
	Control	98.5	99.9	44.7	45.5	2.024	2.031	50.6	49.0

When the results were pooled for the on-farm trial for the 7 farmers in Madang the feed offered to birds on the LELC+C diet was higher than feed offered to birds fed the control layer diet over both months of the trial. The egg weight was slightly higher for birds fed the LELC+C ration throughout (Table 42). FCR of birds fed the control diet was slightly superior than birds fed the LELC+C diet during both months although FCR declined for both treatments during the second month.

The rate of lay of hen for birds in the Madang on-farm trial fed the LELC+C diet was 49.6% while the birds fed the control ration had an egg production of 43.6%. However, rate of lay increased for birds fed both diets during the second month.

Table 42. Comparison of village hen production performance of birds fed a LELC + cassava diet versus a control layer ration for the 7 farmers both trials

Treatments		Feed offered (DM basis) (gm/bird/day)		Egg weight (gm/bird/day)		FCR (feed/egg)		Rate of lay (%)	
	Treatments	Month 1	Month 2	Month 1	Month 2	Month 1	Month 2	Month 1	Month 2
	LELC+C	111.0	112.0	45.2	45.5	2.129	2.297	49.6	58.8

	Control	98.33	99.41	40.1	45.1	1.873	2.13	43.6	56.6

The egg production performance of birds in the two trials was different. In the first trial birds fed the LELC+C diet performed better than those on the control ration, whilst in the second trial birds fed the control ration performed better than birds fed the LELC+C ration. Overall the birds fed the LELC+C performed reasonably compared to those fed the control ration when assessed on the basis of egg weight and rate of lay, despite a slightly inferior FCR.

The trial was successfully carried out by the farmers, despite some difficulties with data collection. From the farmers own observation, they were very pleased with the performance of the birds fed the LELC+C relative to the birds fed the control diet. They recognized the cost advantages of the test diet. This trial was an eye opener for the seven participating farmers and many of the villagers who observed the activity. The trial showed that there is potential for village chickens to have good egg production. This could result in improved income from the sales and a good protein source for the family provided that good management techniques are applied, adequate feed is provided and the LELC+C feeding method is carried out correctly. At the official closing of the trial, there was a high turnout mostly of women and youths, and village elders who wished to get involved. This concentrate feeding technology should be tested in other coastal areas and more results collected from different locations.

The on farm layer trial using Australorp crosses was conducted on 3 farms in the highlands to compare the performance of birds fed the HELC + SP compared to the commercial layer diets. There was no significant difference in egg production %, feed intake, egg weight and FCR despite some numerical differences in feed intake, egg weight and FCR (Table 43). The point to note from the trial with the Australorps cross is the high feed intake (142-148 g/b/d) which reflects the higher body weight of the strain and higher propensity for feed wastage due to birds flicking the feed out of the hopper. Birds aged 19-26 weeks would be expected to consume about 120 g/day. Nevertheless reasonable egg production and egg weight was achieved during the 8 weeks of the trial which indicates the potential to use the Australorp crosses and fed with the concentrate as a replacement for commercial layer feed. Analysis of the feed costs also showed that there was no difference between the diets used (Table 44). However further trials with the concentrate over the full laying cycle (18-66 weeks) are required to establish the role of concentrate feeds in the smallholder layer industry. The performance of laying hens are very sensitive to minor dietary deficiencies but in this case the Australorp cross performed quite well and gives encouragement for farmers to use local feed resources in the smallholder layer industry. (Costings of local feed resources in Appendix 2)

Table 43. Body weight, egg production %, feed intake, egg weight and FCR of Australorp crosses fed HELC +SP vs. a commercial layer diet from 19-27 weeks in highland on-farm layer trials

Treatments	Body weights (Kg)		Egg production (%)	Intake DM Basis (g/hen/day)	Egg weight (g)	FCR (kg of feed/kg of egg)
	Age 19 weeks	Age 26 weeks				
Standard	1.85a	2.073a	61a	142.8a	60.3a	2.85a
HELC + SP	1.87a	2.196a	60a	148.5a	63.0a	3.05a
Grand mean	1.86	2.135	60.2	145.7	61.5	2.95
P-Value	0.921	0.57	0.86	0.4	0.725	0.64
SEM	0.187	0.141	50.5	4.24	5.19	0.39
CV %	17.4	11.4	14.5	5.1	14.6	16.4

Means with the common letter within columns are not significantly different at P>0.05

Table 44. Cost of feed and production costs for Australorp crosses fed HELC +SP vs a commercial layer diet from 19-26 weeks in highland on-farm layer trial.

Treatments	Cost of feed (PGK/egg)	Cost of a dozen (PGK)	Production cost (PGK)
Standard	0.34a	4.03a	18.79a
HELC + SP	0.35a	4.19a	19.54a
Grand mean	0.34	4.11	19.17
P-Value	0.400	0.400	0.40000
SEM	0.010	0.171	0.796
CV %	5.1	5.1	5.3

Means with the common letter are not significantly different at P>0.05

The on farm layer trial using Hyline Brown layers was conducted on 4 farms in the highlands to compare the performance of birds fed the HELC + SP compared to the commercial layer diets. (Hyline Brown layers are a commercial strain that is imported into PNG and also used worldwide). There was no significant difference the diets based on bird body weight, egg production %, feed intake, egg weight and FCR despite some numerical differences in feed intake, egg weight and FCR (Table 45). The Hyline Brown birds had just reached maturity. It was not expected that the rate of lay of the birds would have reached peak egg production. While there was no significant difference in the performances of birds (possible due to limited replication of the on-farm trials), birds fed the HELC+SP lagged behind in production, feed intake, egg weight and FCR compared to birds fed the commercial diet. The commercial layers have been selected by geneticists to maximise their performance on diets that meet all their nutritional needs under optimal environmental conditions which are difficult to achieve in the PNG smallholder environment. Analysis of the feed costs showed that there was no difference between the diets used (Table 46) but the HELC+SP diet had a lower numerical cost. The Australorp crosses have proven to be adaptable to the PNG environment and performed better than the commercial hybrids. It should be noted that farmers growing their own sweet potato are excess to their requirements and famers tend not to put a value on the cost of feeding sweet potato to birds.

Table 45. Body weight, egg production %, feed intake, egg weight and FCR of Hyline Brown layers fed HELC +SP vs. a commercial layer diet from 19-26 weeks in on-farm layer trial in the PNG highlands

Treatments	Body weights (Kg)		Hen house production (HHP)	Intake DM Bais (g/hen/day)	Egg weight (g)	Feed conversion (kg of feed/kg of egg)
	Start	End				
Standard	1.40a	1.712a	53a	123.8a	54.3a	3.02a
HELC + SP	1.41a	1.747a	40a	114.2a	50.1a	3.95a
Grand mean	1.40	1.729	46	119	52.4	3.49
P-Value	0.985	0.859	0.25	0.56	0.561	0.42
SEM	0.266	0.135	7.3	4.35	4.35	0.76

CV %	53.2	15.6	31.8	16.6	24.4	43.9

Means with the common letter are not significantly different at P>0.05

Table 46. Cost of feed and production costs for Australorp crosses fed HELC +SP vs a commercial layer diet from 19-26 weeks in on-farm layer trial in the PNG highlands

Treatments	Cost of feed (PGK/egg)	Cost of a dozen (PGK)	Production cost (PGK)
Standard	0.25a	2.97a	13.87a
HELC + SP	0.23a	2.74a	12.80a
Grand mean	0.24	2.86	13.33
P-Value	0.657	0.657	0.657
SEM	0.029	0.348	1.625
CV %	24.4	24.4	24.4

Means with the common letter are not significantly different at P>0.05

8.2.4 Monitor the performance of the broilers, inputs and costs, and sale price to assess profitability of various feeding options.

Comparative costing of locally milled (“mini mill”) high protein concentrate based on local feed stocks was compared to the price of the commercially available alternative in the highlands and lowlands of PNG.

The comparison of village operation feeding costs (feed plus labour) of rations was based on; 1) a mini mill made concentrate plus local carbohydrate source - sweet potato (highlands) or cassava (lowlands), 2) a commercial made high protein concentrate plus local carbohydrate source, 3) a dilution strategy of half normal commercial feed plus local carbohydrate source compared to commercial feed and 4) a benefit-cost analysis of this latest project together with the preceding poultry project.

1. The costs of feeding broilers in PNG village operations: a comparison of different feed sources

The price of mini-mill produced high protein concentrate.

This was derived from first principles. Tables 47, 48 & 49 show the steps involved: derivation of a fixed asset annual overhead cost (Table 47), annual running costs (Table 40), and raw material feed costs (part Table 47).

Table 47. Medium sized mini mill capital costs (pelleter is optional for poultry feeds)

	Cost (kina)	Amortisation (Years)	Annual Cost
Capital			
Land	5000	20	250
Fence	2000	10	200
Sheds	4700	20	235
Roads, compaction, etc	3000	2	1500
Mini Mill			
Hammer Mill (including electric or diesel motor)	5533	5	

Drying/roasting cauldron	7216		
Mixer (including electric motor)	2350	5	
Pelleter (including electric or diesel motor)	7216	5	
Heating fire box using local fuels	1848	5	
Scales	1000	5	
Power supply and connection to machinery	8000	5	
Hand cutting and handling tools	100	5	
Storage & materials movement equipment	300	5	
Total	**33563**	**5**	**6712.6**
Office equipment	10000	5	2000
Bags, bins etc	4500	10	450
Vehicle	22500	5	4500
(second hand)			
	118826		15847.6

Table 48. Mini mill annual operating costs

	Lowlands	**Highlands**
	(Kina)	(Kina)
Fuel	16000	20000
Municipal rates	5000	5000
Power	5000	5000
Phone	5000	5000
Night Security	6000	6000
Office supplies	2000	2000
Pest control	1000	1000
Labour:		
Skilled Manual labourer	8000	8000
Repairs & maintenance & replacement	6000	6000
TOTAL	54000	58000

Note: bulk ingredient transport costs are added to bulk ingredient costs, for example in Table 45; 50K/t in lowlands, 250K/t in highlands

Table 49. Costs and mark-ups for a mini mill producing high energy concentrate in the lowlands

Ingredient prices and example cost/tonne			
	Kina/tonne	**kg used in a 1 tonne mix**	**Cost/revenue (kina)**
High Protein			
Fishmeal	1150	333	382.95
Copra meal	750	333	249.75
High Energy			
Coconut oil	1250	50	62.5
Low cost by-product			
Mill run (bran/pollard)	330	283	93.39

Premix	6000	1	6
Total			732.09
400 tonne/year (10 tonne/wk for 40 weeks/year for running mill)			292836
Annualised capital cost			15847.6
Operating			54000
Total			362683.6
Inclusive of profit margin (30%)			471488.68
Price per tonne (mini-mill gate)			1179
Price per tonne (retailer (+30%))			1532

Feeding costs in a village farm operation

Table 50 shows the feeding costs of a lowland high energy concentrate diet together with cassava. Table 51shows the equivalent costs for a commercial concentrate plus cassava diet. Table 52 shows the costing with a dilution of commercial feed with a local carbohydrate (cassava in the case of the lowlands). An additional labour cost was factored in to take account of cooking the local carbohydrate source. Table 51 shows a costing of the commercial feed as a complete source.

Table 50. Lowlands village feeding costs: mini mill concentrate plus cassava

	Quantity	Unit	Price (kina)	Total cost Or Revenue
COSTS PER BATCH OF BIRDS				
Mini Mill LE concentrate	60	kg	1.55	93
(farm gate price inclusive of transport)				
Major feed sources:				
(market prices less transport cost)				
Root crops				
Cassava fresh	200	kg	0.6	120
(energy source added to concentrate)				
Labour	50	hours	1.25	62.5
Day old chicks	52	chicks		115
Mortality	3	birds		
Age to market	50	days		
TOTAL COST PER BATCH				390.5
REVENUE PER BATCH				
live bird sales	50	birds	20	1000
BATCH OPERATION SURPLUS				609.5
Annual turn over (batches/year)	4	batches		
OPERATION SURPLUS PER YEAR				2438

Table 51. Lowlands village feeding costs: commercial concentrate plus cassava

	Quantity	Unit	Price (Kina)	Total cost or revenue
COSTS PER BATCH OF BIRDS				
commercial mill concentrate	50	kg	2.7	135
(farm gate price inclusive of transport)				
Major feed sources:				
(market prices less transport cost)				
Root crops				

Cassava fresh	200	kg	0.6	120
(energy source added to concentrate)				
Labour	50	hours	1.25	62.5
Day old chicks	52	chicks		115
Mortality	3	birds		
Age to market	50	days		
TOTAL COST PER BATCH				432.5
REVENUE PER BATCH				
live bird sales	50	birds	20	1000
BATCH OPERATION SURPLUS				567.5
Annual turn over (batches/year)	4	batches		
OPERATION SURPLUS PER YEAR				2270

Table 52. Lowlands village feeding costs: commercial feed

	Quantity	Unit	Price (kina)	Total cost or revenue
COSTS PER BATCH OF BIRDS				
Feed Mill commercial	200	kg	2	400
(farm gate price inclusive of transport)				
(Complete feed as is)				
Labour	25	hours	1.25	31.25
Day old chicks	52	chicks		115
Mortality	3	birds		
Age to market	50	days		
TOTAL COST PER BATCH				546.25
REVENUE PER BATCH				
live bird sales	50	birds	20	1000
BATCH OPERATION SURPLUS				453.75
Annual turn over (batches/year)	4	batches		
OPERATION SURPLUS PER YEAR				1815

Table 53. Lowlands village feeding costs: commercial feed diluted with cassava

	Quantity	Unit	Price (kina)	Total cost or revenue
COSTS PER BATCH OF BIRDS				
Feed Mill commercial	100	kg	2	200
(farm gate price inclusive of transport)				
(Complete feed as is)				
Root crops				
Cassava fresh	140	kg	0.6	84
(energy source added to concentrate)				
Labour	40	hours	1.25	50
Day old chicks	52	chicks		115
Mortality	3	birds		
Age to market	50	days		
TOTAL COST PER BATCH			365	
REVENUE PER BATCH				

live bird sales	50	birds	20	1000
BATCH OPERATION SURPLUS			635	
Annual turn over (batches/year)	4	batches		
OPERATION SURPLUS PER YEAR			2540	

Table 53 shows a comparison of feeding costs per chicken batch. Apart from the labour costs between full commercial feed and the concentrate or dilution strategy, noted above, the differences between highlands and lowlands costs are due to differences in the market price of cassava in the lowlands (60 toya/kg) and sweet potato in the highlands (70 toya/kg) as well as differences in the bulk ingredient transport costs, as reflected in retail prices at point of sale to villagers. A transport cost of 250 K/t has been used in the highlands and 50 K/t in the lowlands, reflecting current information. Table 51 shows the relative costs, using commercial feed as the denominator.

Table 54. Village feeding costs per batch of 52 chickens

	Kina
Lowlands mini mill HEC + cassava	276
Lowlands commercial concentrate + cassava	318
Lowlands diluted commercial feed	334
Lowlands commercial feed	431
Highlands mini mill LEC + sweet potato	311
Highlands commercial concentrate + sweet potato	350
Highlands diluted commercial feed	359
Highlands commercial feed	481

Table 55. Village feeding costs comparison

(lowlands mini mill HEC + cassava)/(lowlands commercial feed)	0.64
(lowlands commercial concentrate + cassava)/(lowlands commercial feed)	0.74
(lowlands diluted commercial feed)/(lowlands commercial feed)	0.77
(highlands mini mill LEC + sweet potato)/(highlands commercial feed)	0.65
(highlands commercial concentrate + sweet potato)/(highlands commercial feed)	0.73
(highlands diluted commercial feed)/(highlands commercial feed)	0.75

Table 54 shows that all diets where a local carbohydrate source is substituted for all or some commercial feed show distinct cost advantages for village broiler operations.

It should be noted that the cost of a commercial concentrate (Table 51) at this stage is based on grain legume prices being at least 50% more than feed wheat prices. In particular, the combination of a mini mill concentrate based on local ingredients plus a local carbohydrate source appears very attractive.

While the cost advantages for feeding regimes utilising local feed sources look considerable, it does not necessarily imply complete or near complete adoption of the new technologies. Sweet potato and cassava are grown using hand labour and little or no mechanisation in a de-enervating climate where malaria, particularly in the lowlands, and other diseases are endemic. Therefore the marginal social cost of growing sweet potato or cassava may be significantly higher than the market cost used here. In contrast, commercial feed can be used in village operations with little associated labour. These social considerations contra indicate rapid and complete adoption of the new technologies.

2). An ex-ante benefit-cost analysis of the economic impact of the two programs

Analysis was carried out using the DREAM program V3.0.0 (Wood, You and Baitx 2001). The program was run in the “closed economy” mode, as all village grown broilers are consumed within village communities, often through sale in local markets.

Market penetration: Although there is considerable interest at village demonstration trial levels in this program, we have chosen a market penetration of these new technologies, resulting from the R, D & E program of 35%. We assume a sigmoid adoption rate over 9 years commencing one year after cessation of the extension of the R&D by the extension NGOs involved. We suggest these figures are conservative.

Sensitivity Analysis-We used assumptions of 20% and 50% market penetration.

Break-even analysis-We tested the concept of absolute minimum market penetration to check that the program was worthwhile in financial terms.

Costs are in PNG Kina. They include the full ACIAR research costs (including previous projects) as well as the full financial and in-kind costs of the PNG contributor organisations.

Benefits-Table 48 forms the basis of the benefits, together with the estimated 6 M p.a. village broiler production. We have little prior knowledge of which of the new technologies is likely to predominate. Although the mini-mill technology is notably cheaper than the other technologies, it is by no means certain that the PNG mainland will be covered by a viable network of mini-mills producing poultry feed. Hence we used the mean of a 29% reduction in feeding costs of village broilers from the three new feeding regimes.

A discount rate of 5% p.a. was used.

Following Alston, Norton and Pardey (2006), we used a price/production elasticity of 1.0 and a price/consumption elasticity of 0.5 in the DREAM program.

Given this stimulus of reduced feed costs to the market for village broilers, we have assumed that the market will grow by 1% p.a., also taking into consideration the convenience and changing tastes towards poultry meat within PNG village communities.

A benefit stream of 25 years was used, with no dis-adoption of the technologies, except in favour of possible superior technologies in the future. That is, newer technologies will improve on these technologies under consideration, in terms of further productivity gains.

Table 56 shows the results from the core assumptions and sensitivity analyses.

Table 56. Benefit-cost analysis results

	Internal rate of return (%)	Benefit-cost ratio (:1)	Net present value (M Kina)	Producer benefits (M Kina)	Consume r benefits (M Kina)
Core assumption: 35% market penetration	25	15	45,596	16,282	32,685
Sensitivity analysis: 20% market penetration	20	9	24,488	9,246	18,492
Sensitivity analysis: 50% market penetration	27	22	66,965	23,405	46,810

R & D costs were estimated at 3.251 M kina which includes a previous poultry ACIAR project in PNG.

The break-even analysis showed that a market penetration of <1% would allow the cost of the two programs to be covered by the value of the benefits.

Clearly the conservative core estimates of market penetration, as well as the break-even analysis, indicate that the R D & E programs have been well worthwhile. It remains to be seen which technology makes the greatest contribution. While the calculations indicate that the mini-mill technology is superior, as stated above, it is not clear that the PNG mainland will be adequately covered with a set of mills to meet village requirements. A range of small business skills are required to run such operations. In addition continuity of local high protein supplies such as copra and palm kernel meal, particularly in the highlands, remains problematical. Also, as stated above, the convenience of purchase of fully formulated rations mitigates against a rapid and complete adoption of the new technologies.

This work offers a template for similar sorts of adoptions in other Pacific Island nations. In addition, it offers a template for other avian and porcine feeding systems in the Pacific. Of interest, also in this context, is the suggestion that for localities where high protein copra meal or palm kernel meal is readily available but local sources of carbohydrate are expensive, it is feasible to transport high energy concentrate to villages as a dilution for these meals.

8.3 Objective 3: To promote the wide-spread adoption of alternative feeding options for broilers that will improve profitability.

8.3.1 Produce and up-date information for use in NGO extension service leaflets and village training material.

Extension materials on feeding options were developed for use by NGO's in village training. The fact sheets show pictures of the method to feed the concentrate with sweet potato or cassava.

Figure 4. Diet Preparation Fact Sheet for Cassava and the Concentrate Feed

Figure 5. Diet Preparation Fact Sheet for Sweet Potato and Concentrate Feed

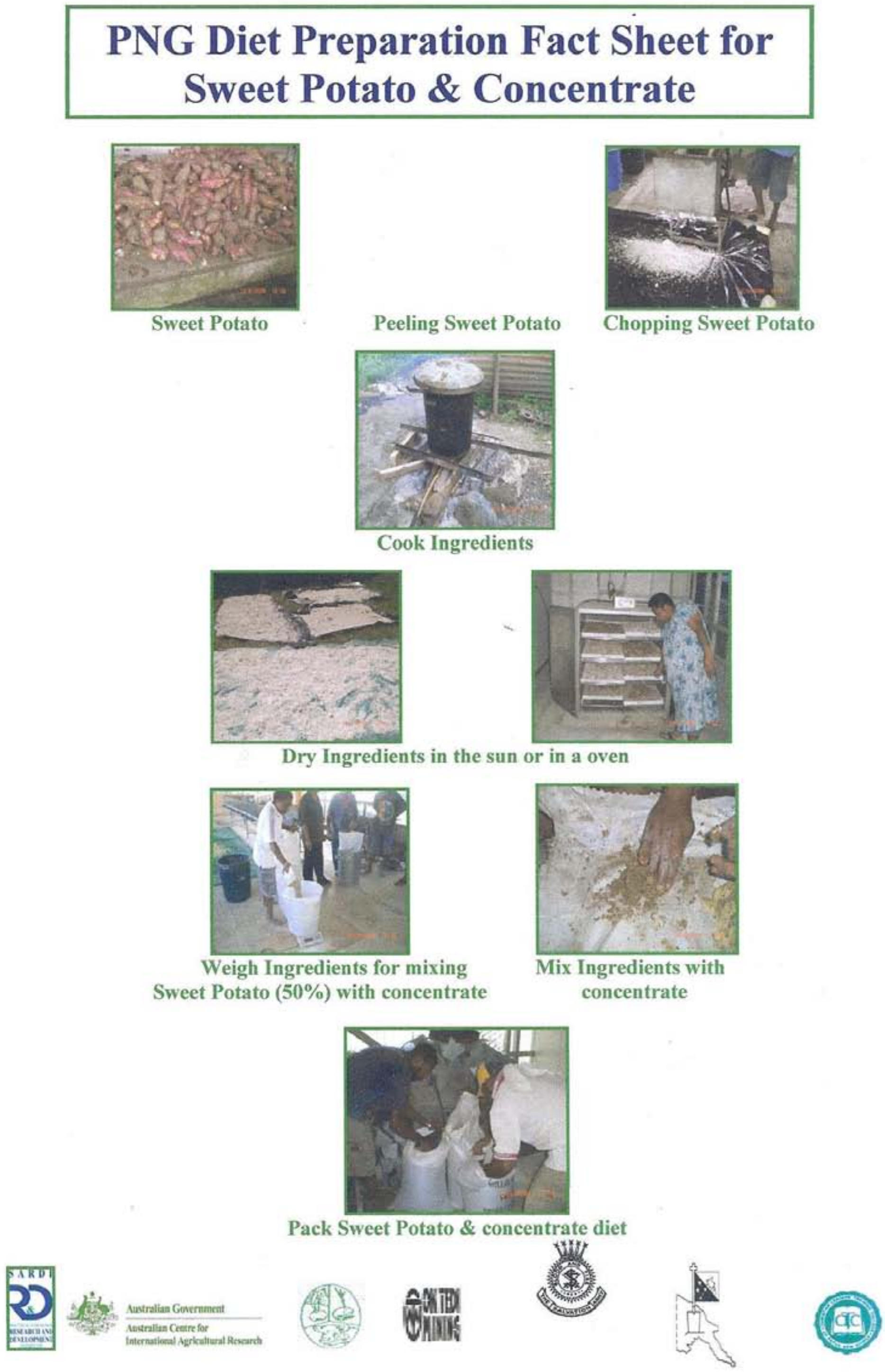


Figure 6. How to make the sweet potato based diet to feed broilers and layers

Step 1. Collect and wash tubers

Step 2. Boil

Step 3. Drain and cool

Step 4. Mash the boiled tubers

Step 5. For broilers mix thoroughly one part of concentrate with three parts of sweet potato.For layers use 3 parts of the layer concentrate and 2 parts of cooked sweet potato

Step 6. Feed birds

Fig 7. How to make the cassava based diet to feed to broilers and layers

Step 1. Collect tubers

Step 2. Peel and Clean

Step 3. Boil

How to make the cassava based diet

Step 4. For broilers use one part of concentrate with three parts of cassava.

For layers use 3 parts of the layer concentrate and 2 parts of cooked cassava.

Step 5. Mix it thoroughly

Step 6. Feed Birds

8.3.2 CLTC and LDS poultry production curriculum

Feed ingredient sheets were developed to provide a general guideline for the use of ingredients for poultry and pigs in PNG. They include fruit, roots, legumes, cereal grains, by products and miscellaneous ingredients. Each fact sheet contains the name, general description, brief details on nutritive value and anti-nutritional factors for each ingredient. The ingredient fact sheets are available from the author on request.

8.3.3 Conduct annual workshops and seminars

A poultry workshop titled "Improving Poultry Production in Developing Countries in SE Asia and the Pacific Region" was run at the CLV Conference Centre at the University of Sydney Village from 4-5 February 2009. The workshop was funded by AusAid, WPSA, Australian Egg Corporation Limited, Biomin, Chemin and Aviagen. The workshop was attended by participants from East Timor, PNG, Solomon Islands and Tonga who had previously or are currently involved with the current ACIAR poultry feed project. Key note speakers at the workshop included experts from around Australia and New Zealand. To reinforce the opportunities available to improve poultry production in SE Asia and the Pacific region the workshop was held to deliver practical information on feeding, housing, health, egg and meat quality and food safety in village poultry. These sessions were followed by group discussions on “sustainability and social equity issues for the global poultry industry; impact in developing countries of the world” and “priority village poultry issues to resolve in SE Asia and the Pacific Region”.

The participants at the workshop were; Pedro De Deus (Ministry of Agriculture and Fisheries) and Eduardo Serrao (University of Queensland and University of Timor) both from Timor Leste; Dr Workneh Ayalew (NARI), Janet Pandi (NARI), Andrew Mari (Ok Tedi) and Elizabeth Tu (Child Fund) all from PNG; Fatuimoana Langilangi (Ministry of Training, Employment, Youth and Sports) and Toifalefehi Moala (Ministry of Agriculture, Food, Forests and Fisheries) both from Tonga and Joseph Wahanui (Solomon Islands College of Higher Education) and Hearly Aleve (Department of Agriculture and Livestock) from the Solomon Islands.

The first annual review meeting for the project was held at CLTC, Banz Campus from 29-30 July 2009 and was attended by 15 participants representing NARI, SA, UniTech, LDS, Project Support Services and SARDI. This was followed by the second annual review meeting on Wednesday 11th November 2009 held in the Allan Quartermain Hall in Lae, PNG. The meeting involved 31 people including project participants from SARDI, NARI, LDS, OK Tedi, CLTC, Project Support Services and representatives from ACIAR, Presidents of the World and the Australian body of the WPSA, DAL (Highlands, Fisheries and Madang) and industry representatives from Goodman Fielder International, NGTB and Crest Mills (Fiji). Briefings were given on progress with the project and the success being achieved with the concentrate feeding systems.

The third annual review meeting took place in the Allan Quartermain Hall, Lae, PNG on 21 February 2012 to further assess progress on the project. The meeting was attended by 28 participants and included Emily Flowers (ACIAR PNG country manager) and representatives from NGTB and Zenag Poultry. The final review meeting was held at the Momahi conference room in Lae on 29 November 2012 and was attended by 17 participants including Dr Caroline Lemerle (ACIAR ASEM Program Manager). This final review meeting was followed by an adopt workshop led by Geoff Kuehne (CSIRO) and Roger Wilkinson (VicDPI) (Appendix 4). The workshop was conducted to determine if the broiler feeding system was suited to PNG village poultry operations and the extent of adoption of the feeding system in PNG in the highlands, lowlands and outer islands of PNG

8.3.4 Assist NGOs in a coordinated campaign promoting the use of lower-cost feeding regimes

To get the message out to smallholder farmers, village demonstrations were conducted and attachments for key farmers at NGO sites. Details of the feeding method were included in the school and Uni curriculum and in fact sheets. The campaign included publicity at village markets, radio, TV, video and the internet. Field days, training and demonstration sessions were run by NARI and other NGO partners and included distribution of publications (tok toks, bulletins and fact sheets).

A number of newspaper articles and reports on the feeding system were published on the NARI. Fact sheets of feed resources available in PNG for broiler feeding were developed for College, University and NGO curriculums and a video script detailing how to use the feeding systems was written and filmed for playing at field days.

9 Impacts

9.1 Scientific impacts – now and in 5 years

The project has strengthened the capability of NARI, Unitech and NGO's to use sound scientific protocols to conduct on-station and on-farm broiler and layer feeding trials.

The development and production of concentrate diets by commercial feed mills is having an impact on village communities involved in the trials who now wish to expand their broiler production. Farmers have indicated that feed costs are lower and profit higher and this will lead an increase in income for families and reduce poverty. A socio-economic study on the impact of this alternative feeding technology on small-scale broiler production and the villagebroiler marketing systems in PNG is now required.

Broilers are able to utilize significant quantities of sweet potato and cassava in their diets indicating the bird's digestive system is able to adapt quite rapidly to digesting alternative feed stuffs. Studies are currently underway through a PhD by Ms Janet Pandi to examine role of feed enzymes to improve digestibility of PNG ingredients and to profile the micro flora in the gut to understand the adaption mechanisms involved and how greater inclusions of local feeds can be implemented. These studies are also required in laying hens and ducks.

The science impact of the findings from this project are likely to lead to the use of a greater range of feed stuffs in PNG and elsewhere in broiler and layer diets in the next 5 years. An interesting observation reported by farmers who have consumed the meat from birds fed with sweet potato or cassava is that the meat tastes better. This observation requires further evaluation and if found to be validated could have significant impact on diets used in PNG to feed broilers in the future. A market study on sales of live poultry fed with local ingredients vs. imported ingredients would identify if consumers prefer buying birds fed with local feeds.

There are benefits of the outputs from this project to the commercial layer and broiler production sector, particularly if imported input costs continue to rise sharply. Novel PNG feed sources fed with the concentrate could generate new information on how to improve digestibility of feed in broilers.

Evidence emerged from the NGO demonstration trials that type of housing has a key impact on performance of birds fed the concentrate diets which may lead to new housing designs for village and semi commercial poultry operations, particularly the use of eco shelters.

9.2 Capacity impacts – now and in 5 years

The development of personnel capacity in this project is intended to improve the sustainability of activities beyond the life of financial support from ACIAR. Activities included:

Livestock officers from CLTC, LDS, Ok Tedi and the SA were trained in the operation of their demonstration grow-out facilities and how to feed the poultry concentrate with local energy sources.

Staff operating mini-mills were trained in feed formulation and mixing of concentrate diets was conducted at a number of sites.

Unitech post graduate and under-graduate students undertook activities in the project to obtain costings of feed ingredients in the lowland provinces.

A close working relationship developed with the scientists, the NGO's (CLTC, SA, LDS, and Ok Tedi) and the commercial feed companies (Lae Feed Mills, NGTB, Crest Mills in PNG and nutrition consultants). During the village trials, the farmers worked closely with NARI and the NGO's to validate and demonstrate the broiler and layer feeding system. These activities involved training in the methodology required to operate a field trial and capacity building of the farmers during the visits made by NGO and NARI staff. The training of livestock farmers, extension staff and technicians was completed. A number of trained farmers have supported other farmers to run trials not officially involved in the project.

9.3 Community impacts – now and in 5 years

The village broiler production industry involves about 55,000 families producing 6.76M birds/annum with an estimated value of $67M. When combined with the layer sector the number of farmers involved in poultry production in PNG is approximately 220,000. Many of these farmers keep poultry in a small scale commercial enterprise to generate income. Demonstration of the concentrate feeding system in all the poultry sectors is estimated to benefit the PNG economy by $30m/annum.

Live birds and eggs are sold from the household or in local markets. Women predominate in running these small enterprises. Most poultry farmers are located in the Morobe, Madang and the Highland Provinces, largely in response to the cost and accessibility of inputs. In the highlands demand for meat chickens is growing. The increase in cost of commercial feed continues to pose the greatest threat to this sector, as the market for live birds is very price sensitive, so farmers are unable to pass on the higher cost of inputs except in area close to mines where live poultry and eggs achieve a premium price. In this situation profitability can only be sustained or improved by reducing input costs; 60-80% of which are for feeds. The benefits from the concentrate/local feed option include the development of an alternative market for the local feeds (e.g. sweet potato, taro, yams, and cassava) and the wider geographic distribution of layer and broiler enterprises. The broiler concentrate is currently been sold in the highlands in smaller volumes (1-5 kg) and these quantities can be more easily transported to remote regions.

9.3.1 Economic impacts

Economic analyses were undertaken on costs associated with running a significant sized mini-mill operation to produce poultry concentrate and a village broiler enterprise. At approximately K800/t, mini-mill concentrate is more than competitive with commercial full rations (K2000/t) and a commercial concentrate (K2400/t). The mini-mill concentrate price is based on provisional costing of local ingredients and mini-mill equipment, as well as setup and running costs. Fishmeal, copra meal, mill run and premix are the ingredients intended to be used to produce the concentrate. The technology will achieve village enterprise broiler production market penetration if the local based feed ingredient price including labour is less than 70 percent of the import based feed ingredient price including labour (more labour is required for the local based feed technology). The calculations indicate that the mini-mill concentrate plus local carbohydrate including labour represents 56% of the full commercial feed plus labour costs, and the commercial concentrate concept plus local carbohydrate and labour is 69% of the full costs. Hence both "local" feed systems could achieve market penetration, but especially the mini-mill concentrate system. The local carbohydrate source was either sweet potato or cassava at K0.7-1.0/kg in the lowlands and highlands.

An ex-ante benefit-cost analysis of the economic impact of the R, D & E program to improve the profitability of village broiler production in PNG was carried out. The research and development aspects of the program have developed a mini-mill approach for the provision to villagers of a high protein concentrate based on local feed sources, to be combined with a local carbohydrate source such as sweet potato in the highlands and cassava in the lowlands. However, other options include a commercial feed high protein concentrate plus local carbohydrate source and a dilution strategy of half normal commercial feed plus local carbohydrate source. Our estimate of the program costs was 3.3 M kina in mid financial year 2008/2009 values. On our core assumption of 35 percent market penetration of these new technologies, the analysis showed an internal rate of return to the program of 25 % p.a., a net present value of 45.6 M kina and a benefit-cost ratio of 15:1. The benefits were attributed to a producer surplus of 16.3 M kina and a consumer surplus of 32.7 M kina. The analysis was robust in terms of showing that the program is of good value in terms of a low-end market penetration of 20% and a break-even market penetration of <1 %.

9.3.2 Social impacts

The majority of smallholder broiler producers/sellers are women who retain the income for family activities. The improvement in profitability from the improved feeding systems and an increase in broiler production can improve the position of women in the community as family income increases.

9.3.3 Environmental impacts

There are no anticipated changes to the environmental status of smallholder broiler production in PNG from this project. Current smallholder broiler production systems are well integrated with other feed production activities, with manure collected and mainly used as fertilizer in the feed gardens. Feeds do not contain antibiotics and these small-scale systems are remarkably free of disease and pest problems.

9.4 Communication and dissemination activities

The project inception meeting took place in the Allan Quartermain multipurpose hall, on 15 August 2007 from 9.15 AM – 3 PM. Present at the meeting were; Cathy Pianga (ACIAR); Dr Raghanuth Ghodake (NARI); Prof A. Halim (UniTech); Lawrence Williams (CLTC); Klaus Neumeier (LDS); Christine Gee (Salvation Army); Gregory Denn (PSS Ltd); Ian Black (SARDI); Phil Glatz (SARDI); Dr Workneh Ayalew (NARI); William Kerua (UniTech); Peter Manus (UniTech); Thomas Kulum (CLTC); Wandamu Palau (NARI); Birte Komolong (NARI); Sergie Bang (NARI); William Nano (Unitech); Jesse Anjen (NARI); Eleo Dowa (NARI), Janet Pandi (NARI); Matt Carr (GEF/World Bank); Jasaking Kigasung (LDS/YD); Janet Deklin (NARI); Bonnie Keoka (LDS); Otenili Pifeleti (MAFFF); Peter R Vete (Farmer, Tonga); Chris Mari (Farmer, Tonga); and Lath Vehikite (Farmer, Tonga). The objective of the meeting was to clearly define the objectives of the project and the responsibilities of each of the partners in achieving the milestones.

The first annual review meeting took place at the Christian Leaders Training College, Banz Campus, Banz from 29-30 July 2008 in the guest house. Present at the meeting were; Klaus Neumeier (LDS); Christine Gee (Salvation Army); Gregory Denn (PSS Ltd); Ian Black (SARDI); Phil Glatz (SARDI); DR Workneh Ayalew (NARI); William Kerua (UniTech); Thomas Kulum (CLTC); William Nano (Unitech); Janet Pandi (NARI); Joe Josiah (LDS), Bevan Egger (LDS); Douglas Maip (UniTech); Donal Bong (CLTC); Las Kombra (CLTC). The objective of the meeting was for partners to present results on progress of the project and to clearly define the year 2 objectives and milestones of the project expected from partners.

The second annual review meeting took place in the Allan Quartermain Hall, Lae, PNG on 11 November 2009 to assess progress on the project. The meeting was attended by participants in the project and included Emily Flowers (ACIAR PNG country manager), representatives from stock feed companies in Lae and Fiji and the Presidents of the World and Australian body of the World's Poultry Science Association. Involved in the meeting were; Esther Igo (Goodman Fielder PNG), Eugene de Lange (Goodman Fielder PNG), Ron Mason (National Operations Manager, Goodman Fielder), Bob Pym (President

WPSA), Emily Flowers (ACIAR), Wally Solato (DAL Fisheries), Joe Alois (DAL Highlands), Julie Roberts (WPSA & UNE), John Konga (NARI), Bonnie Keoka (LDS), Teria Kevere (LDS), Andrew B Mari (Ok Tedi), Gray Tuno (Ok Tedi), Fred Besari (NARI), Thomas Kulam (CLTC), Auton Kaupa (CLTC), Johannes Kovop (NGTB), Simon Sangi (NARI), Millicent Yalu (NARI), Doug Preston (NGTB), James Tarabu (NARI), Seniorl Aulzy (NARI), James Duks (DAL- Erap), Gregory Denn (Project Support Services Ltd), Johannes Pakatul (NARI Higher Altitude) and Ganet Agodop (DAL Madang). The objective of the meeting was for partners to present results on progress of the project and to clearly define the year 3 objectives and milestones of the project expected from partners.

The third annual review meeting took place in the Allan Quartermain Hall, Lae, PNG on 21 February 2011 to further assess progress on the project. The meeting was attended by 28 participants in the project but also Emily Flowers (ACIAR PNG country manager) and representatives from NGTB and Zenag Poultry. Participants at the meeting included Dr Workneh Ayalew (NARI), Dr Ian Black, Dr Phil Glatz and Theo Simos (SARDI), Glen Kenneally (JCU), Brian Ilsin and Miape Baupupu (OTDF), Anton Kaupa (CLTC), Jacob Wani (NFA), Prof Abdul Halim, Dr Gariba Danbaro and Dr Peter Manus (Unitech), Janet Pandi (NARI), David Drummond (NGTB), Stanley Leahy (Poultry Industry Association), Bonnie Keoka, Ulrike Hartmann-Mitz and Hans Wilhelm Ehmig (LDS), Dr Norah Omot, Michael Dom, Fred Besari, Eleo Dowa, Dr Pikah Kohun, Monica Mazi, James Tarabu and Densley Tapat (NARI), Maria Linibi, Mary Aitobu, Susan Iris and Lisset Ambung (Women in Agriculture). The objective of the meeting was for partners to present results on progress of the project and to clearly define the year 3 objectives and milestones of the project expected from partners.

The final review meeting was held at the Momahi conference room in Lae on 29 November 2012 and was attended by 17 participants including Dr Caroline Lemerle (ACIAR ASEM Program Manager). This final review meeting was followed by an adopt workshop led by Geoff Kuehne (CSIRO) and Roger Wilkinson (VicDPI). The workshop was conducted to determine if the broiler feeding system was suited to PNG village poultry operations and the extent of adoption of the feeding system in PNG in the highlands, lowlands and outer islands of PNG. Other participants at the meeting included Ms. Rebecca Bogosia (ACIAR), Dr. Mark Booth (NSWDPI), Mr. Havini Vera (NFA), Theo Simos (SARDI), Joseph Corey (CLTC), Liam Flanagan (B4MD), Moses Pala (Farmer), Thomas Kulum (Domil), Jason Pundu (B4MD), Dr Workneh Ayalew, Dr Norah Omot, Dr Pikah Kohun, Fred Besari, Elly Solomon, Arthur Roberts and Maima Sine (NARI), Dr Gariba Danbaro (NARI), Mr. Bonnie Keoka (LDS) and Phil Glatz (SARDI).

10 Conclusions and recommendations

10.1 Conclusions

Improving the profitability of village broiler farming through the use of locally available feedstuffs is a high priority in the PNG livestock sector. The viability of village broiler farms is threatened by the rising costs of imported ingredients used in commercial feeds. An earlier ACIAR project developed a feeding system whereby PNG protein meals (plus minerals and vitamins) were used to produce a concentrate that could be fed to broilers with 50-80% of local ingredients. The feeding method resulted in good bird growth.

This project focused on delivery of feeding strategies to village farmers through the participation of Non Government Organisations (NGO's) which included Christian Leader Training College (CLTC) in the highlands, Lutheran Development Service (LDS) in the lowlands and OK Tedi Development Foundation in the Western Province.

Initially the Apparent Metabolisable Energy (AME) was evaluated for concentrate diets that had low energy (AME 9.6 MJ/kg, Crude Protein (CP) 40%), medium energy (AME 10.5MJ/kg, CP 43.5%) and high energy (AME 11.7 MJ/kg, CP 41%) at NARI broiler feed evaluation unit in Lae. The diets were evaluated by NARI with the most suitable being; 1) 50% sweet potato + 50% low energy concentrate; 2) 70% sweet potato + 30% low energy concentrate; and 3) 50% cassava + 50% high energy concentrate. These diets were then tested in regional broiler grow-out trials by the NGO's.

The diets with the greatest potential in the Highlands Provinces was 50% of the low energy concentrate supplemented with 50% of sweet potato. The diet best suited for lowland chicken meat production was 50% high energy concentrate supplemented with 50% cassava. Regional village broiler feeding trials were run at Mahalang, Finschafen and Madang in the lowlands; in the Banz and Kainantu districts in the highlands and at Kiunga, Star Mountains and Tabubil in the Western Province. Broilers performance (particularly the sweet potato diet) compared favourably with standard feed in all the village farm trials. Birds reached market weight (>2 kg) soon after 5 weeks of age.

Most of the village farmers involved with the trials indicated an interest to continue using the concentrate mix. Some farmers wanted more information about other alternative feed resources to use with the concentrate especially in the coastal regions. The feeding system is appropriate and boosts village broiler income by reducing the cost of feeding broilers.

To determine if the feeding strategy will be adopted by village farmers an economic assessment was made to determine the cost of locally milled broiler concentrate compared to the price of the commercially available alternative at several key sites in PNG. At approximately K800/t, mini-mill concentrate is more than competitive with commercial full rations (K2000/t) and a commercial concentrate (K2400/t). Based on these costs, mini mill products based on local feedstuffs are highly competitive, particularly for copra/palm kernel meals.

It was considered appropriate to demonstrate if the feeding system developed for broilers based on using a concentrate mixed with sweet potato or cassava could be adapted for use in indigenous poultry, imported hybrid layers and Australorps crosses to reduce feed costs. The demand for eggs is increasing in PNG as the mining industry and associated support industries expand.

Two concentrate rations for laying hens were formulated; one that could be fed with sweet potato and the other with cassava. The sweet potato diet (HELC+SP) had an apparent metabolisable energy (AME) of 11.8 MJ/kg and contained 40% of cooked sweet potato. The cassava (40% inclusion rate) diet (LELC+C) had an AME of 10.9MJ/kg.

To test these diets laying hen facilities at NARI were used. Hens fed on LELC + C diet performed better than birds fed on the HELC + SP diet and the standard diet. The use of village chickens, locally bred hybrid crosses and commercial hybrids fed with sweet potato or cassava based diets was considered beneficial for further testing at NGO sites.

To evaluate the performance of birds on the SP and C based diets, trials with commercial hybrids and village chickens were conducted at NGO partner sites. (CLTC in the highlands and LDS in the lowlands). In the highlands commercial hybrids fed the SP and C based rations had lower feed intake relative to the control birds, they produced fewer eggs and had lower egg weight but feed conversion was superior.

In the lowlands village hens fed on SP and C based rations had higher egg production compared to birds fed on the commercial ration but had poorer feed conversion. On the basis of cost it was determined that the most affective feeding option for layer type birds was the SP based diet. The commercial layer concentrate was the most costly. On-farm layers trials were then run in the highlands and in the lowlands. In the lowlands birds fed the LELC+C diet performed better than the commercial diet when assessed on the basis of average egg weight and FCR. The farmers were very pleased with the performance of the birds fed the LELC+C diet. In the highlands however there no difference in the performance of layers whther they were fed the commercial layer diet or the SP based diet.

The greatest potential for providing smallholder poultry farmers with cheaper feed is to encourage the manufacture of feed through regionally based mini mills. The Domil Integrated Community Development Cooperative Society located in the Jiwaka Province in the highlands of PNG opened its model mini mill in April 2012. The products from the mill are cassava flour, cassava starch and broiler cassava finisher feed which is being sold to farmer members of the cooperative. The broilers are grown out by farmer members of Domil and sold back to the cooperative. The birds are processed and packed at the mill site and then sold in Mount Hagen. There was a 12% savings in feed costs at the Domil mill compared to using commercial feed.

Strategies implemented to publicise the benefits of the broiler and layer feeding system in PNG included field days, training and demonstration sessions run by NARI and other NGO partners and distribution of publications. NARI and partners also used radio and TV programs, newspaper articles and reports on the NARI website to disseminate the feeding strategies. Fact sheets of feed resources available in PNG for broiler and layer feeding were developed for College, University and NGO curriculums. A video on how to use the feeding systems was produced.

10.2 Recommendations

Marketing

The broiler and layer farmers involved in the feeding trials in the Lowlands and the Highlands are enthusiastic about the feeding system. Trade store owners are purchasing the concentrate and re-pack and retail under NARI supervision. In addition the Porgera Joint Venture- Sustainability Project and Oil Search are keen to be involved producing boilers using the feeding system. There is a need to develop a marketing research project with key Industry stakeholders to develop strategies to distribute the concentrate nationwide.

Research

Further research is required to improve the performance of laying hens fed the poultry concentrate. The studies to date have examined the performance of birds over short periods of the laying cycle and need to be extended to cover the full laying period. The laying hen has various production phases over the 18-66 week laying cycle. Diets can be developed using PNG ingredients that meet the dietary requirements of hens in each phase (peak, mid and late phase). Studies are also required with hens to examine the role of feed enzymes to improve digestibility of PNG ingredients and to profile the micro flora in the gut to understand the adaption mechanisms involved and how greater inclusions of local feeds can be implemented.

Chicken Meat Taste

An interesting observation reported by farmers who have consumed the meat from birds fed with sweet potato or cassava is that the meat tastes better. This observation requires further evaluation and if found to be valid could have significant impact on marketing of meat and eggs of birds fed PNG ingredients.

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Ravindran, V and R. Sivakanesan, (1996). Replacement of maize with sweet potato (Ipomoea batatas L.) tuber meal in broiler diets. British Poultry Science, 37 (1) 95-103.

Sonaiya, E. B. (2013) In: Feed Resources for smallholder poultry in Nigeria. http://www.fao.org/livestock/agap/war/warall/V4440b/v4440b0a.htm

Wood S, You L & Baitx W (2001) DREAM Version 3. IFFPRI, Washington DC.

11.2 List of publications produced by project

Publications and reports on the project were as follows;

Ayalew, W. (2010). Piloting and outreach to better link livestock research with extension: experience from PNG. Australian Poultry Science Symposium Invited Speaker

Ayalew, W. (2011). Improved use of local feed resources for mitigating the effects of escalating food prices in PNG: a contribution for food security policy dialogue. Food Security Policy Conference on High Food Prices in PNG, 06-08 September 2011, NRI, Port Moresby

Black, I.D. and M. Yalu (2010). An ex-ante benefit-cost analysis of the impact of the research, development and extension programme that provided feeding strategies to improve the profitability of village broiler production in Papua New Guinea. Journal of South Pacific Agriculture 14, (1 & 2) 23-27.

Dom, M. and J. Pandi (2011). What can analytical chemistry contribute in Agricultural systems research towards achieving PNG Vision 2050? Food Security Policy Conference on High Food Prices in PNG, 06-08 September 2011, NRI, Port Moresby

Glatz, P. C. (2010). Broiler management in SE Asia and the Pacific Region. WPSA Workshop: Improving poultry production in developing countries in the SE Asia Pacific region. Pp.13-14

Glatz, P. C. (2010). Broiler housing in SE Asia and the Pacific Region. WPSA Workshop: Improving poultry production in developing countries in the SE Asia Pacific region. P. 17.

Glatz, P. C. and B.K. Rodda (2010). WPSA Workshop: Improving poultry production in developing countries in the SE Asia Pacific region, Feb 3-5, University of Sydney. Final Report to AusAid

Glatz, P.C. (2012). Sustainable Small-Scale Poultry Production: Are Local Feeds a Viable Option for the Pacific Region? Technical Centre for Agricultural and Rural Cooperation, Knowledge for Development website, http://knowledge.cta.int/

Glatz, P.C. (2010). Incubation and hatching - Poultry Development Review, Food and Agriculture Organization of the United Nations, (2010). http://www.fao.org/ag/againfo/themes/documents/poultry/PDR_management_incubation.pdf

Glatz, P.C. (2010). Brooding and management of young chicks - Poultry Development Review", Food and Agriculture Organization of the United Nations. http://www.fao.org/ag/againfo/themes/documents/poultry/PDR_management_brooding.pdf

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Glatz, P.C., Black, I.D., Ayalew, W., Pandi, J.K., Hughes, R.J., Miao, Z.H., Wahanui, J., Jansen, T., Manu, V. and Rodda, B.K. (2010). Opportunities and sustainability of smallholder poultry production in the South Pacific region. Australian Poultry Science Symposium 21: 145-152.

Links to internet reports on the project can be found on the NARI and ABC website. These PNG reports were also published in the PNG Post Courier newspaper

http://www.nari.org.pg/info/news/news_100422.html

http://www.nari.org.pg/info/news/news_091119.html

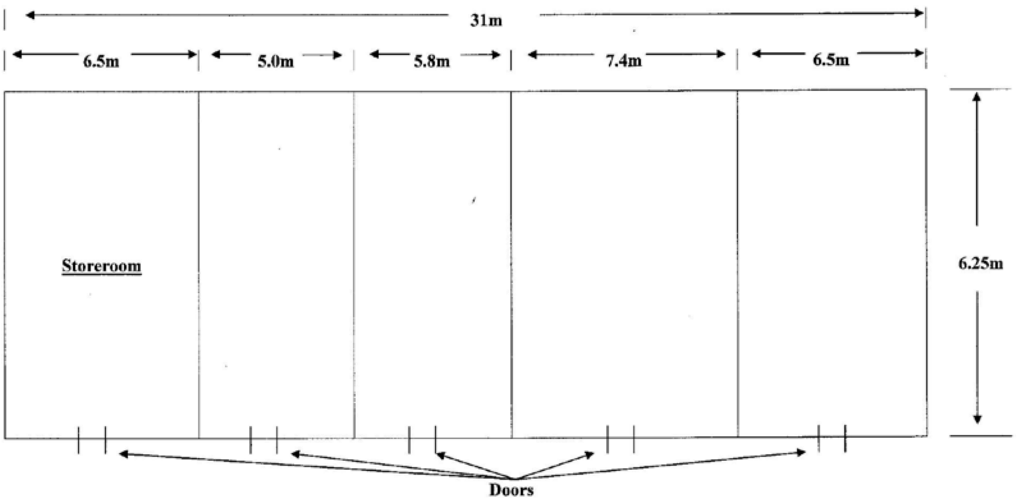
http://www.nari.org.pg/info/news/news_091111.html

http://www.abc.net.au/rural/content/2008/s2642637.htm

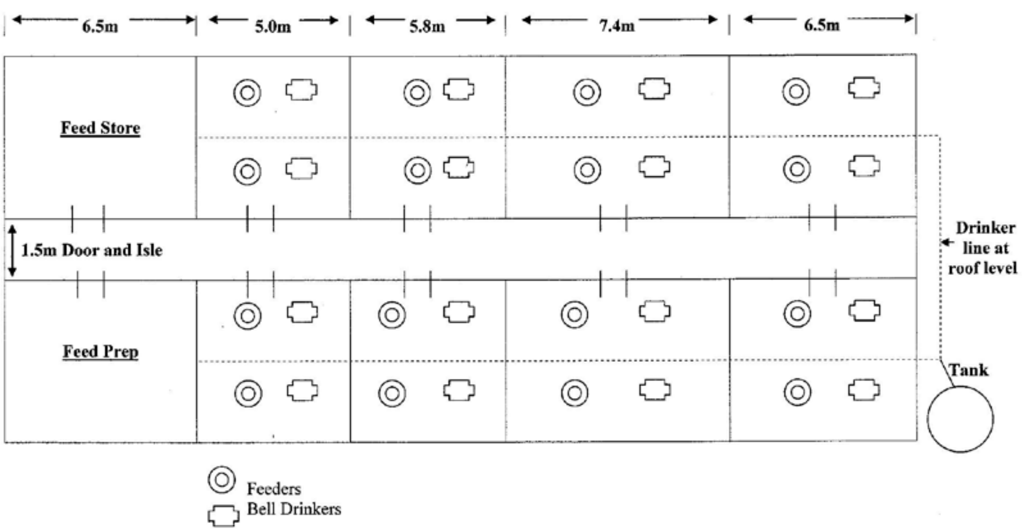
12 Appendixes

12.1 Appendix 1: Shed Layout Drawings

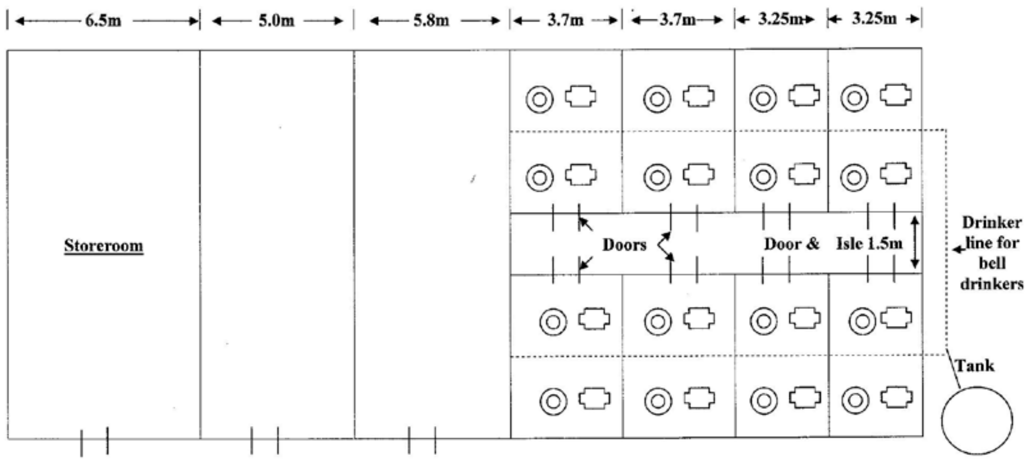
Current Shed Layout at LDS



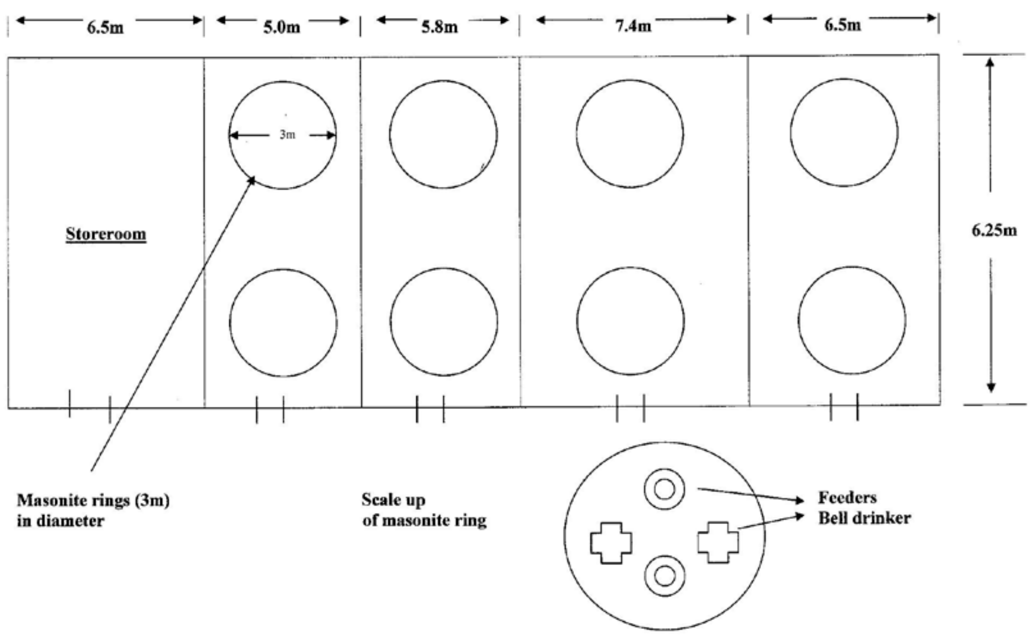
Suggestion 1: Layout at LDS
This option includes a centre aisle in the shed and doorways to each of the 8 pens.



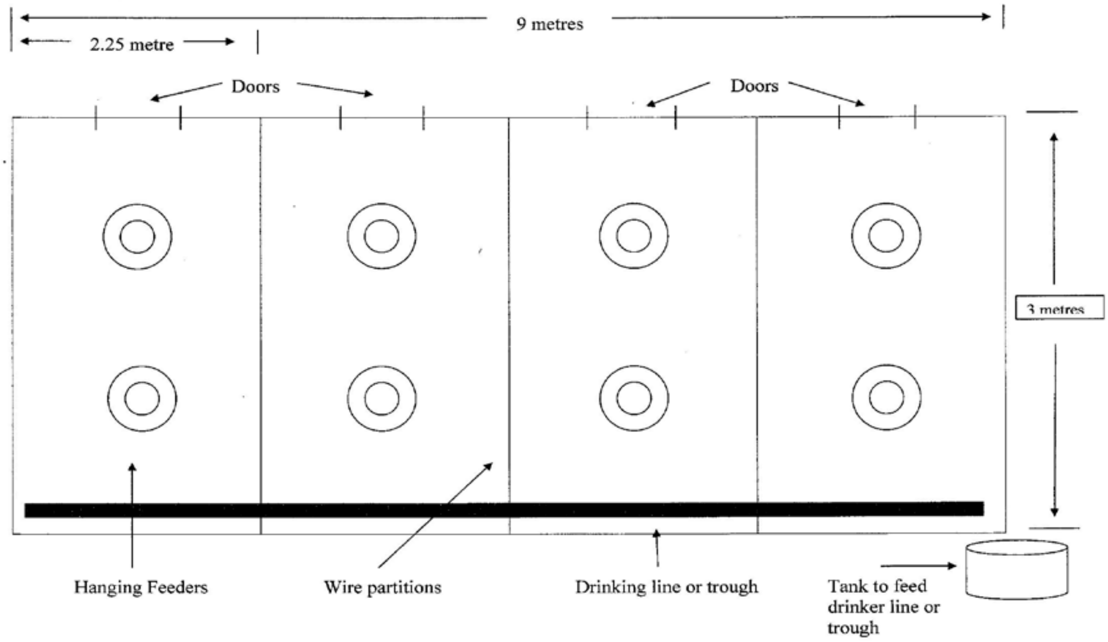
Suggestion 2: Layout at LDS (this option uses only half the shed with centre aisle giving access to the 8 pens)



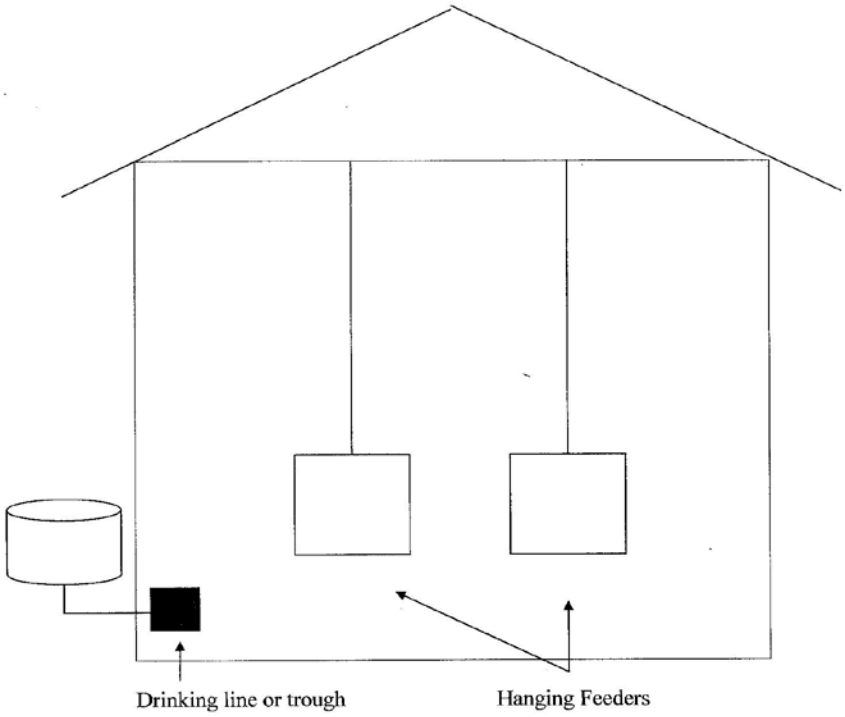
Suggestion 3: Layout at LDS (this option uses the exiting pens with masonite dividers used to segregate groups of birds in each pen)



Layout for Shed at OK Tedi Research Centre (top view)

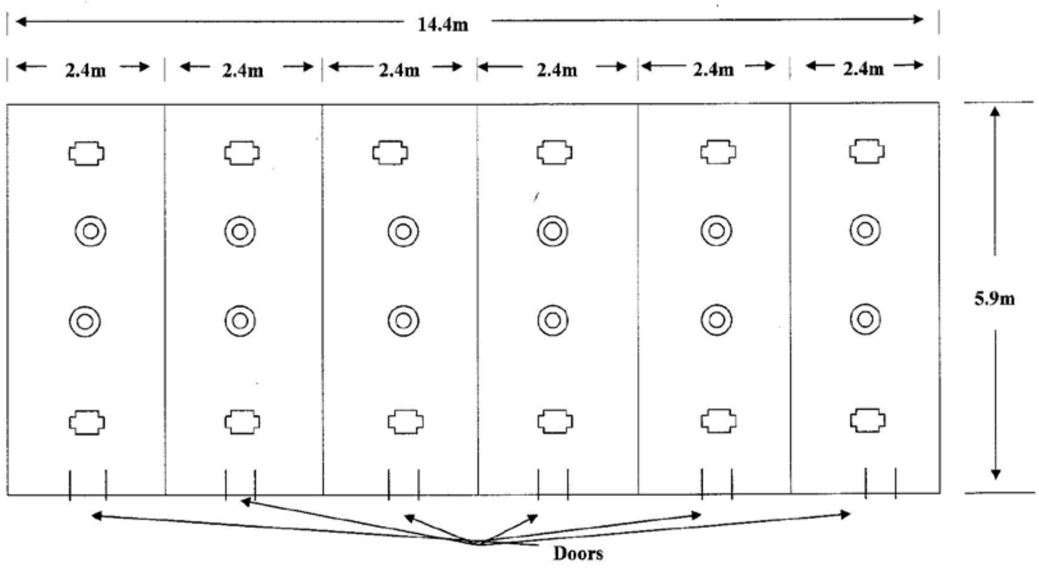


OK Tedi Building Layout – side view

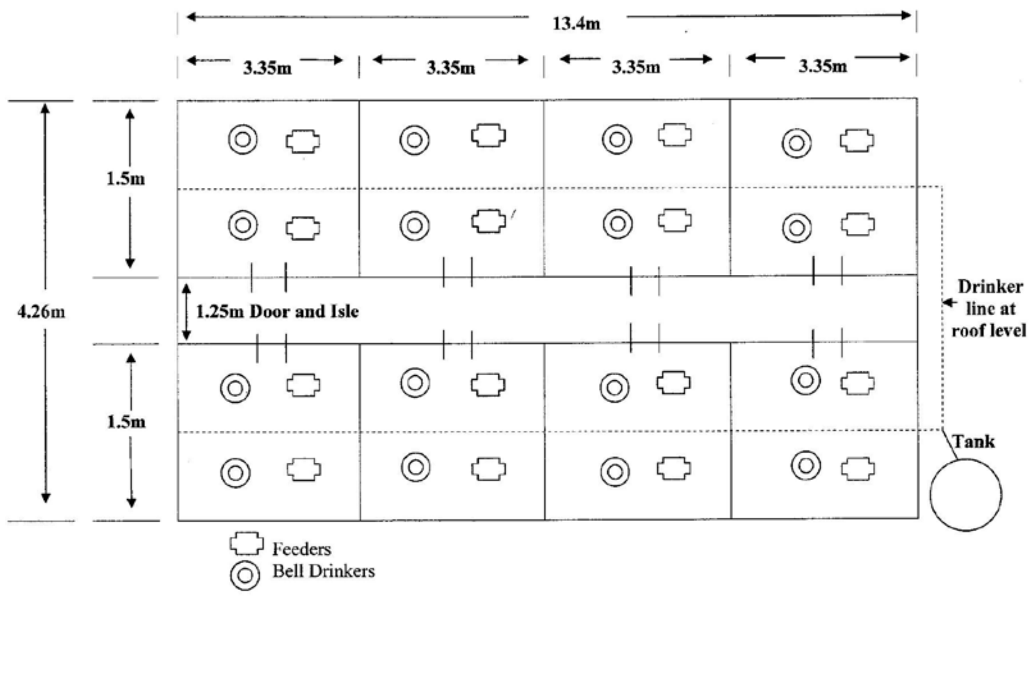


Renovations to CLTC Poultry Facilities for Demonstration Work

Shed 1 – Conversion of Piggery House to Broiler Demonstration Unit



Shed 2. Conversion of Kunai House into Broiler Demonstartion Unit



12.2 Appendix 2: Costings of local feed resources

Table 53. Average price movement of ingredients at Lae Urban Market (Monday 20/04/08 & Saturday 12/07/08) (n=20)

Energy/Starch	Average (Kina/tonne)	Range (Kina /tonne)
Cassava	671.37	142.86 - 1562.50
Sweet Potato	1032.92	819.67 - 1315.79
Taro	1408.06	800.00 - 2884.62
Sago	1815.42	967.74 - 2475.25
Banana	1430.61	750.00 - 2479.34
Corn	1245.46	943.40 - 1428.57
Cow pea	3988.10	2777.78 – 6250.00
Mung Bean	3730.36	1000.00 - 8333.33

Table 54. Average price movement of ingredients at Bumiyong Local Market (Friday 4/07/08) (n=10)

Energy/Starch	Average (Kina/tonne)	Range (Kina /tonne)
Cassava	553.94	160.00 -1000.00
Sweet Potato	728.55	476.19 – 892.86
Taro	1170.73	833.33 – 1677.85
Banana	767.03	200.00 – 1344.08

Table 55. Average price movement of ingredients at Madang Urban Market. (27th June 2008) (n=10)

Energy/Starch	Average (Kina/tonne)	Range (Kina /tonne)
Cassava	561.64	277.77 – 1111.11
Sweet Potato	746.57	555.55 – 1086.95
Taro	1795.23	934.57 – 2380.95
Sago	1772.31	1307.18 – 2464.78
Banana	1517.89	329.67 – 5000.00
Corn	1361.89	1111.11 – 1666.66
Cow pea	4692.4	2941.17 – 10 000
Mung Bean	6287.88	4545.45 – 10 000

Table 56. Average price of high protein ingredients.

High Protein	Average (Kina/tonne)	Range (Kina /tonne)
(By Products & products)		
Fishmeal (RD Tuna)	2310.00	NA
Copra meal (COPM-Madang)	460.00	NA

Table 57. Cost of equipment (Project Support Services Limited – Malahang, Lae)

Capital	Cost (kina)	Amortisation years	Annual Cost (kina)
Mini Mill			
Hammer Mill (FFC 15)	2552.00	5	510.40
Fitted with 3 phase electric motor or			
diesel engine: 1.1kW or 4hp			
Capacity: 15-25kg/hr			
Hammer Mill (FFC 23)	3212.00	5	642.40
Fitted with 3 phase electric motor or			
diesel engine: 3kW or 4hp			
Capacity: 80kg/hr			
Hammer Mill (SJ-400)	5533.00	6	9221.60
Fitted with 3 phase electric motor or			
electric start diesel engine: 11kW			
Capacity: 350-620kg/hr			
Flake Mill (FFC15)	2552.00	4	638.00
Fitted with motor or diesel engine: 3kW			
or 4hp			
Capacity: 20kg/hr			
Flake Mill (FS4020)	5533.00	7	790.43
Fitted with 3 phase electric motor or			
electric start diesel engine: 7.5-11kW			
Capacity: 750-1100kg/hr			
Roll Crusher (280) with 4kW 3phase	4950.00	5	990.00
Electric motor.			
Capacity: 200-300kg/hr			
Mixer			
size 10	93.50	4	23.38
size 12	137.50	4	34.38
size 32	357.50	4	89.38
Pelleter (Diesel or Electric Motor Engine)	7216.00	8	902.00
Scales	110.00	3	36.67
Dryer (Drum Caldron)	5148.00	7	735.43
(fitted with 0.55kW electric motor			
Capacity : 1200-1500 kg/hr			
Heavy Duty Fire Box (with slide rails to	1848.00	4	462.00

suit ZCW 63)			
Grinding Mill	2552.00	5	510.40
fitted with electric motor or diesel engine			
1.5kW or 4hp			
Capacity: 20kg/hr			
Combination Flake Mill (FFC 15) &	3212.00	4	803.00
Grinding Mill			
Fitted with 3 phase electric motor or diesel			
engine: 3kW or 4hp.			
Capacity 30kg/hr			
Hand Mincer/Extruder (#10)	93.50	3	31.17
Hand Mincer/Extruder (#12)	137.50	3	45.83
Hand Mincer/Extruder (#22)	203.50	3	87.83
Hand Mincer/Extruder (#32)	357.50	3	119.17
Hammer Mill (FFC 15)	2552.00	5	510.40
Fitted with 3 phase electric motor or diesel			
engine: 1.1kW or 4hp			
Capacity: 15-25kg/hr			
Hammer Mill (FFC 23)	3212.00	5	642.40
Fitted with 3 phase electric motor or diesel			
engine: 3kW or 4hp			
Capacity: 80kg/hr			
Hammer Mill (SJ-400)	5533.00	6	9221.60
Fitted with 3 phase electric motor or			
electric start diesel engine: 11kW			
Capacity: 350-620kg/hr			

12.3 Appendix 3: Mini mill equipment

Project Support Services Limited (www.psspng.com) supply agricultural machinery and downstream processing equipment as outlined in the above tables.

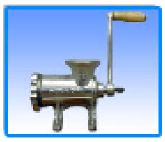
They supply a range of equipment and machinery for use in preparing and producing animal feed.

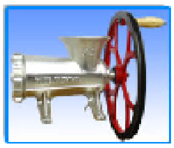
This equipment includes:

Hand operated equipment, choppers, shellers, dehuskers, roll crushers, driers, roasters, boilers, grinders, hammer mills, flake mills, extruders and pellet makers, sieving, weighing and packing equipment.

Project Support Services Limited www.psspng.com

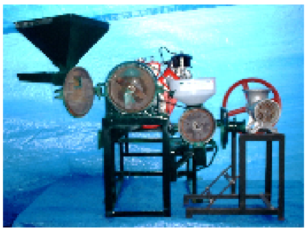
Hand Operated Grinders, Mincers and Extruders



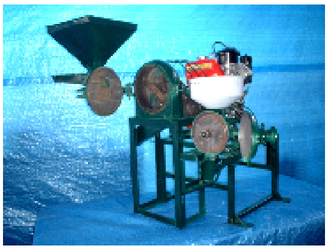


These type of hand operated machines are capable of grinding mincing or extruding feed products and producing feed pellets from approximately 1kg up to approximately 5Kg per hour.

The larger machines can be fitted with pulley belts and are capable of producing up to 25 Kg per hour



Combination machines with Hammer or Flake Mills, grinders and extruders for production rates up to 25 Kg per hour

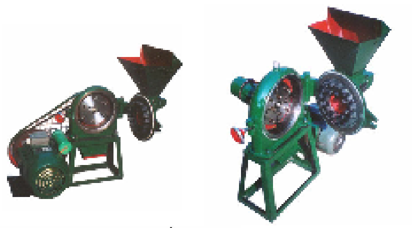


Combination machines can be very practical if very high production rates are not required since they reduce cost and maintenance of drive units - diesel engines or electric motors.

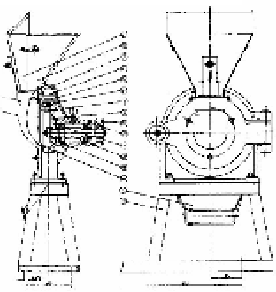
Often a number of different machines are required to cover all types of feed material included in each pellet.

Hammer Mills and Flake Mills

Some machines are general purpose for feed preparation cutting shredding and grinding Others are more specialised as shown here - a cassava cutter

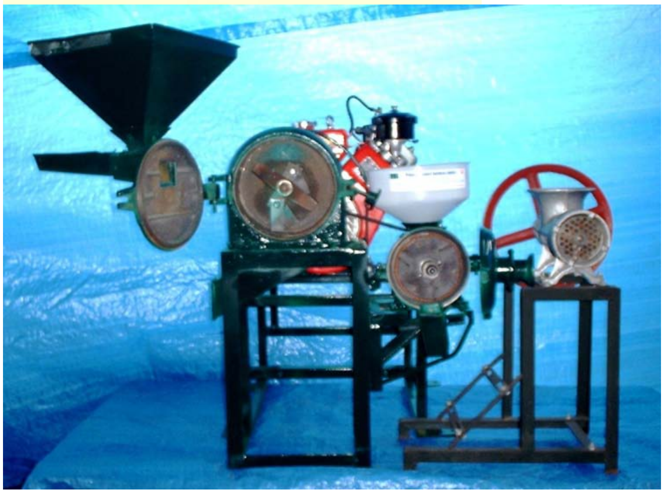


A hammer mill shown set up with a diesel engine that would also operate an attached extruder or grinding mill



Tel : (675) 472 0088 Fax : (675) 472 0044 E-mail : pssltd@daltron.com.pg

Pellet machines



Flake mill

Flake mill

12.4 Appendix 4: Adopt workshop

The adopt workshop was led by Geoff Kuehne (CSIRO) and Roger Wilkinson (VicDPI) and was conducted to determine if the broiler feeding system was suited to PNG village poultry operations and the extent of adoption of the system in PNG. Three teams of PNG participants were asked to use the adopt programs and determine the extent of adoption in the highlands, lowlands and outer islands of PNG.

In the lowlands the year to peak adoption was 22.9 years, in the highlands 24.2 years and the outer islands 19.8 years. The greatest sensitivity in the analysis for each of the assessments was in the questions about the relative advantage of the technology to the population. Broiler farming is part of a number of activities farmers are engaged in and the algorithms may need to be changed to calculate sensitivity of mixed farming activities. The main query about adopt were its relevance to the multi enterprise nature of village farming. In addition there were suggestions that greater emphasis should be placed on social and cultural aspects and also on how to define the target group; whole of country; regional; district or group of villages. The participants in the PNG adopt workshop agreed that adopt could be used before, during or after the project.

Background to adopt workshop

Improving the profitability of village broiler farming through the use of locally available feedstuffs has been a high priority in the PNG livestock sector. Lowland provinces close to the feed mills account for 60% of broiler production with 40% in highland provinces. The viability of village broiler farms has been continually threatened by the rising costs of imported ingredients used in commercial feeds. An earlier ACIAR project developed a feeding system using PNG protein meals (plus minerals and vitamins) that were used to produce a concentrate that could be mixed 50-80% of local ingredients and fed to broilers. The feeding method resulted in good bird growth. ASEM/2005/094 focused on delivery of the feeding system to village farmers through the participation of NGO's which included Christian Leader Training College (CLTC) in the highlands, Lutheran Development Service (LDS) in the lowlands and OK Tedi Development Foundation in the Western Province. The most suitable diets were found to be; 1) 50% sweet potato + 50% low energy concentrate; 2) 70% sweet potato + 30% low energy concentrate; and 3) 50% cassava + 50% high energy concentrate. Village farmers conducted trials to compare the concentrate feeding system with a standard broiler feed. Four regional village broiler feeding trials were run which involved feeding sweet potato with a low energy poultry concentrate to broilers in the highlands and cassava with a high energy concentrate in the lowlands. Broiler performance (particularly the sweet potato diet) compared favourably with standard feed in all the village farm trials. Birds reached market weight (>2 kg) soon after 5 weeks of age. The sweet potato based diet compared very favourably with the commercial control diets.

Most of the village farmers involved with the trials indicated an interest to continue using the concentrate mix. There was also strong interest expressed by other broiler farmers not involved in the trials. Some farmers wanted more information about other alternative feed resources to use with the concentrate especially in the coastal regions. The feeding system is appropriate and boosts village broiler income by reducing the cost of feeding broilers. Strategies implemented to publicise the benefits of the broiler feeding system in PNG included field days, training and demonstration sessions run by NARI and other NGO partners and distribution of publications.

Adopt workshop

The adopt workshop was conducted to determine if the broiler feeding system was suited to PNG village poultry operations and the extent of adoption of the system in PNG.

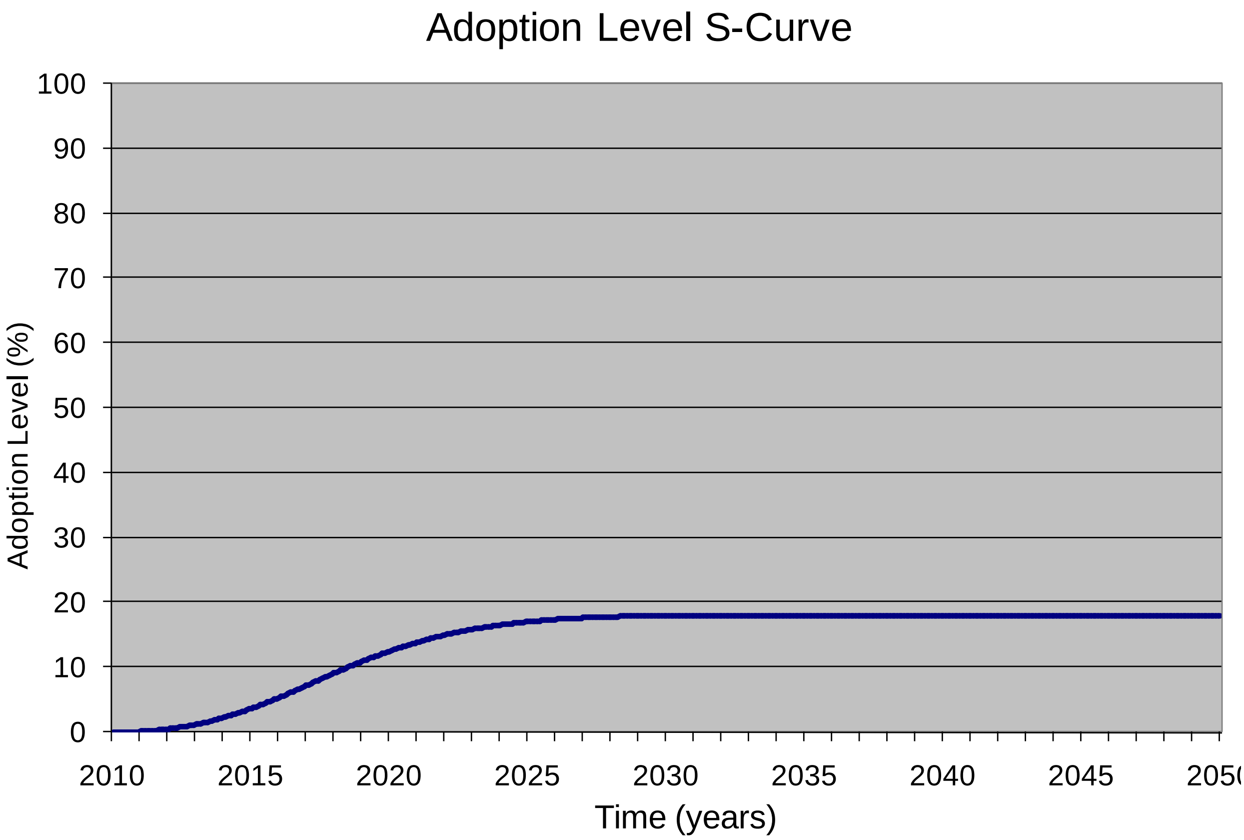
Geoff Kuehne (CSIRO) and Roger Wilkinson (VicDPI) from the adopt team led the workshop. Three teams of PNG participants used the program to predict adoption for 3 different regions in PNG.

Report 1. High Energy Broiler Concentrate blended with Cassava for Villages in Madang Province

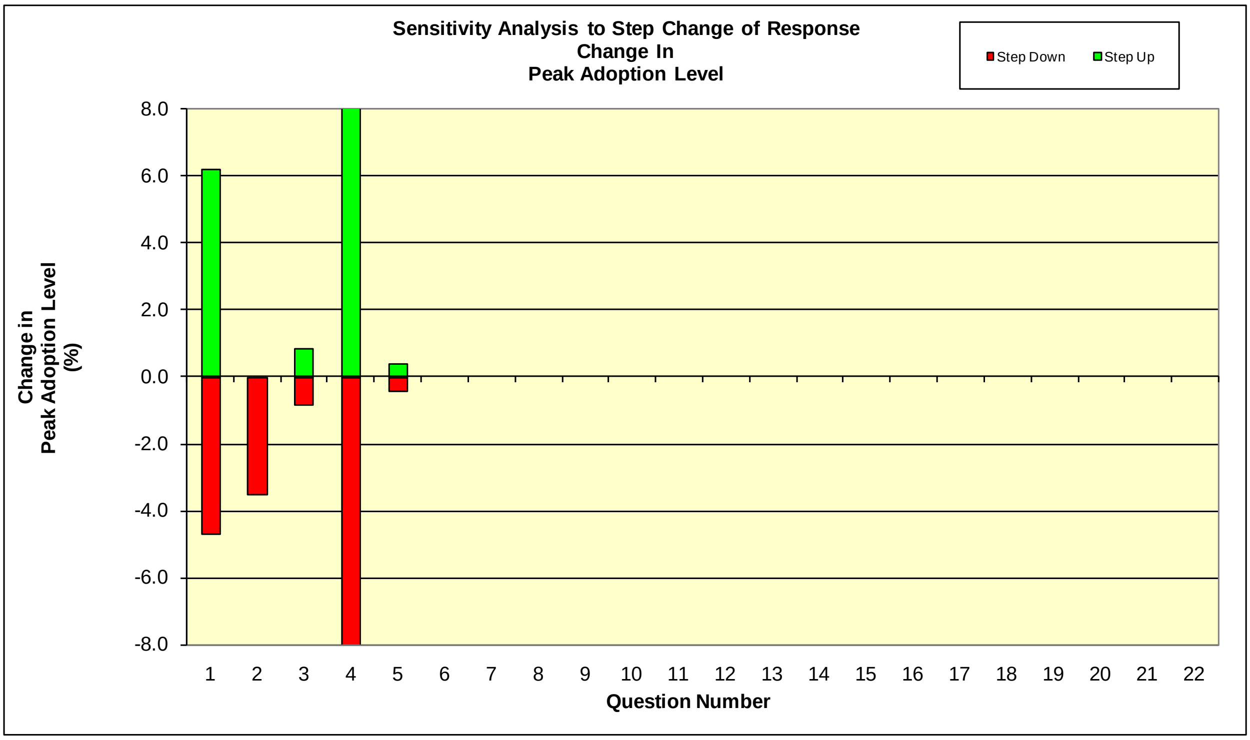
Predicted Adoption Levels

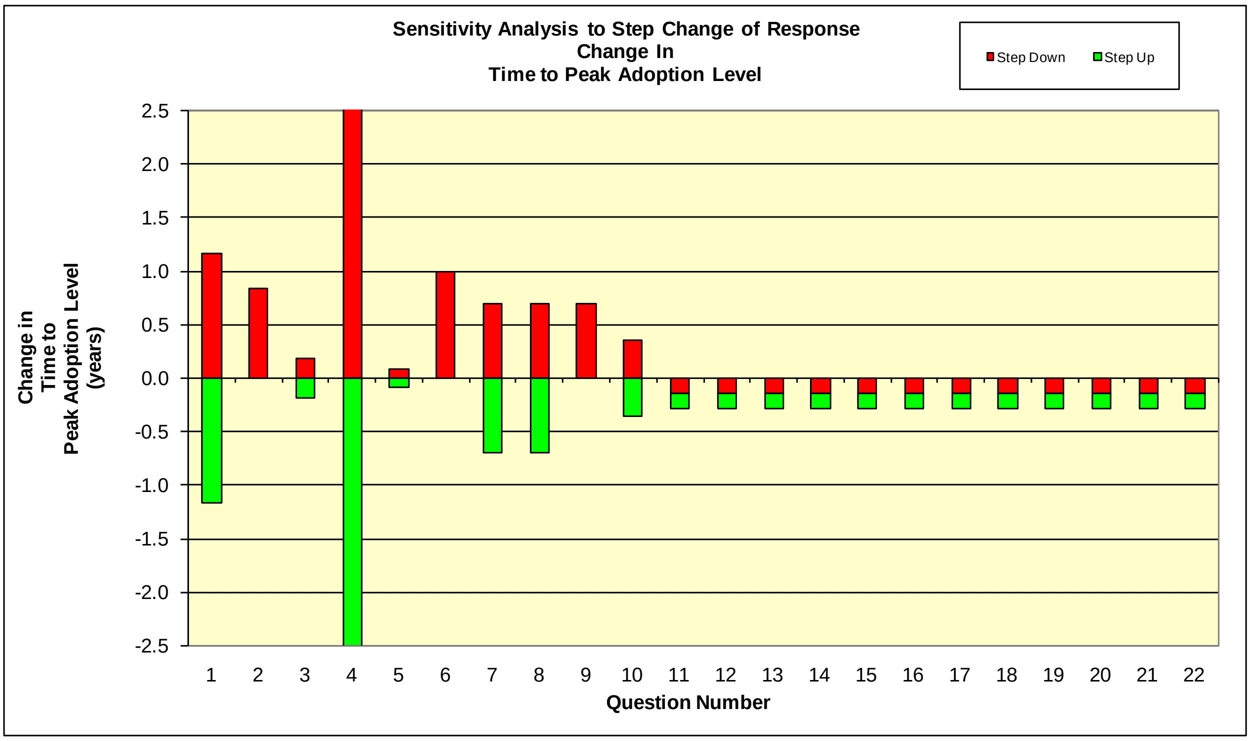
Predicted years to peak adoption	22.9
Predicted peak level of adoption	18%
Year innovation first adopted or expected to be adopted	2010
Year innovation adoption level measured	2012
Adoption level in that year	20%
Predicted adoption level in 5 years from 2012	7.2%
Predicted adoption level in 10 years from 2012	15%

Predicted Adoption Curve



Sensitivity Analysis for Report 1





Information Entered into ADOPT

The above predictions are based on the following information entered into the Adoptability and Diffusion Outcome Prediction Tool for report 1.

Relative Advantage for the Population

Profit/productivity orientation	Response: About half have maximising profit/productivity as a strong motivation
	Reasoning: Broiler chicken meat being the most affordable protein sources in the village after fresh fish.
Local community benefit orientation	Response: Almost all have benefits to their local community as a strong motivation
	Reasoning: The technology targets broiler and cassava farmers as well as those engaged from cash crop activities, thus meat is available.
Risk orientation	Response: A minority have minimising production risk as a strong motivation
	Reasoning: Risk of supply of feed concentrate and day old chicks. Risk of crop failure due to prolonged drought.
Enterprise scale	Response: A minority of the target farms have a major enterprise that could benefit
	Reasoning: Small scale broiler production in the village.
Management horizon	Response: A minority have a long-term management horizon
	Reasoning: Some engaged in the activity on need basis while the minority engaged in long term production in order to meet local demand and maintain profits.
Short term constraints	Response: A minority currently have a severe short-term constraint
	Reasoning: Concentrate not available

Learnability Characteristics of the Innovation

Trialable	Response: Easily trialable
	Reasoning: Availability of the raw materials
Innovation complexity	Response: Slightly difficult to evaluate effects of use due to complexity
	Reasoning: Upgrading of the previous experiences
Observability	Response: Very easily observable

	Reasoning: Observed innovation and learn

Learnability of Population

Advisory support	Response: A minority use a relevant advisor
	Reasoning: Lack of access to information and extension services
Group involvement	Response: A minority are involved with a group that discusses new farming
	Reasoning: Lack of trust and respect
Relevant existing skills & knowledge	Response: About half will need new skills and knowledge
	Reasoning: Most may not have prior knowledge and access to information
Innovation awareness	Response: A minority are aware that it has been used or trialled in their local area
	Reasoning: Involved in other activities.

Relative Advantage of the Innovation

Relative upfront cost of innovation	Response: Moderate initial investment
	Reasoning: Small scale involvement.
Reversibility of innovation	Response: Easily reversed
	Reasoning: Does not require large investment
Profit/productivity benefit in years that it is used	Response: Large profit/productivity advantage in years that it is used
	Reasoning: Cost of production is minimal and the profit is maximized
Future profit/productivity benefit	Response: Large profit/productivity advantage in the future
	Reasoning: Increase in broiler production
Time until any future profit/productivity benefits are likely to be realised	Response: Immediately
	Reasoning: Within 4 weeks of the production period.
Local village/community costs & benefits	Response: Moderate local community/village advantage
	Reasoning: Increase demand in cassava crop and cash income advantages
Time to local village/community benefit	Response: Immediately

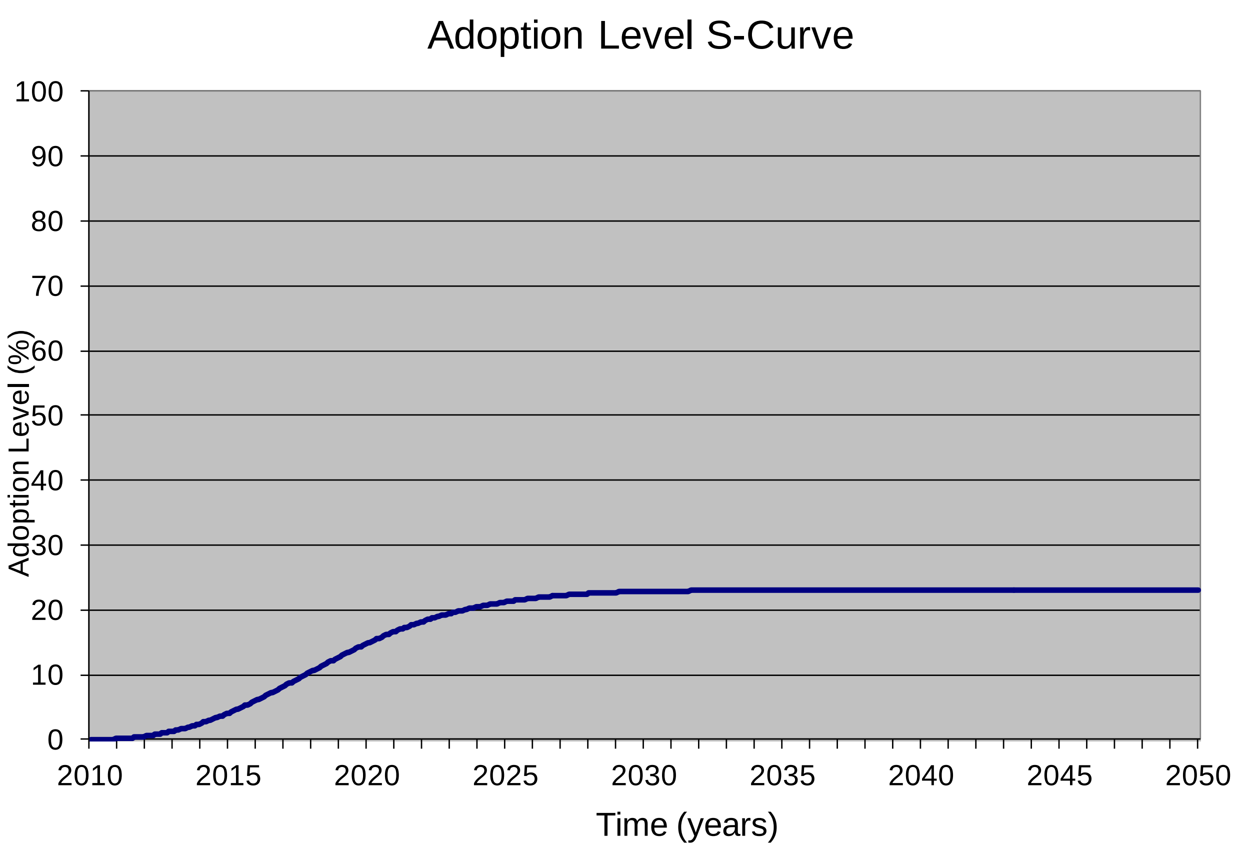
	Reasoning: Cheaper start up capital of the project. When the market is good.
Risk exposure	Response: Reduce risk
	Reasoning: Only if day old chicks are not available or there is increase in cost of day old chicks. Drought also may affect cassava yield.
Ease and convenience	Response: Decrease ease and convenience
	Reasoning: Increase in labourer intensity and time/stress

Report 2. Low Energy Broiler Concentrate blended with Sweet Potato for Villages in the Highland Regions

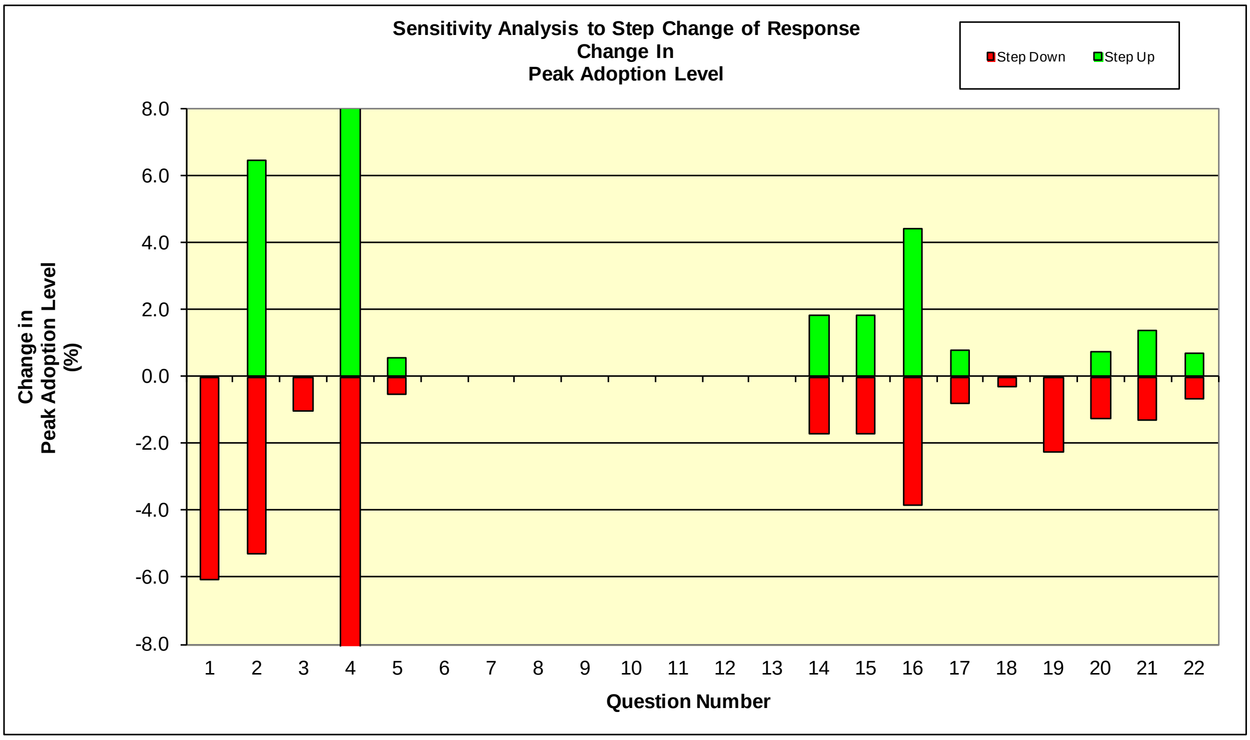
Predicted Adoption Levels

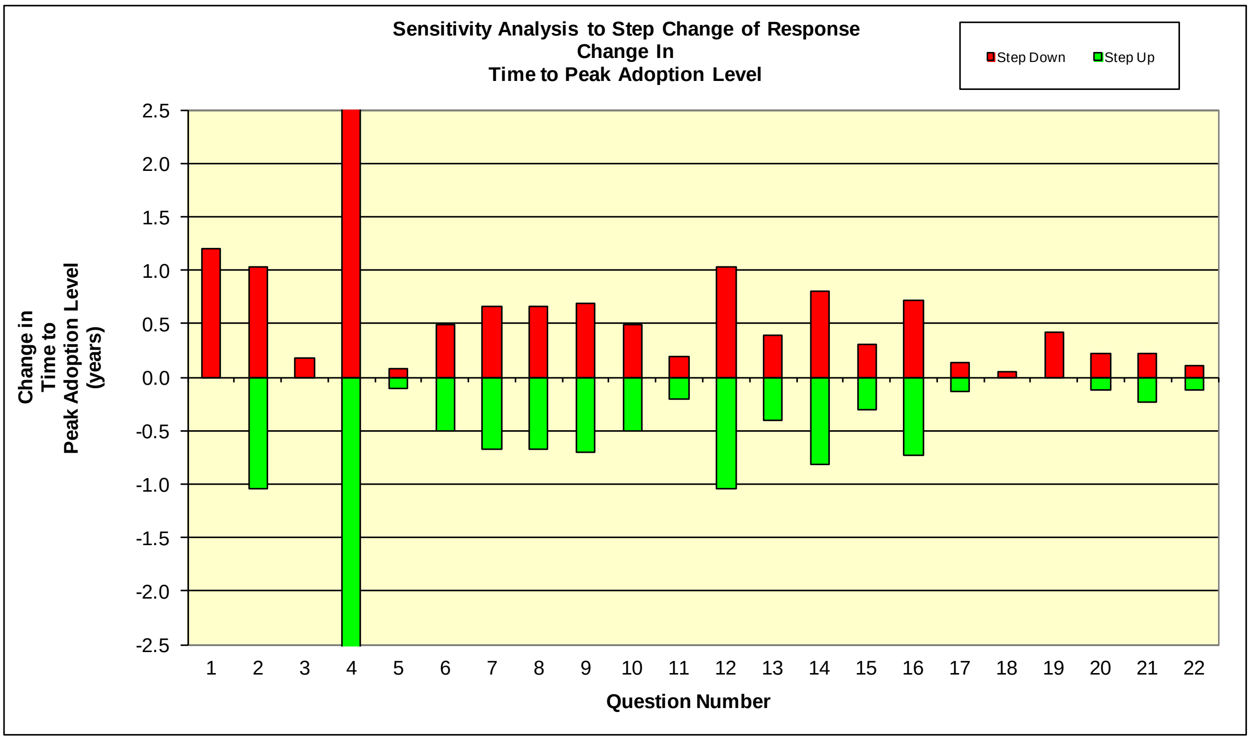
Predicted years to peak adoption	24.2
Predicted peak level of adoption	23%
Year innovation first adopted or expected to be adopted	2010
Year innovation adoption level measured	2013
Adoption level in that year	0%
Predicted adoption level in 5 years from 2012	8.3%
Predicted adoption level in 10 years from 2012	18.3%

Predicted Adoption Curve



Sensitivity Analysis for report 2





Information Entered into ADOPT

The above predictions are based on the following information entered into the Adoptability and Diffusion Outcome Prediction Tool.

Relative Advantage for the Population

Profit/productivity orientation	Response: Almost all have maximising profit/productivity as a strong motivation
	Reasoning: Mostly a small family business orientated activity where birds are sold live
Local community benefit orientation	Response: A minority have benefits to their local community as a strong motivation
	Reasoning: At a household, strong motivation is to benefit the household
Risk orientation	Response: Almost all have minimising production risk as a strong motivation
	Reasoning: The motivation is to maximise profit
Enterprise scale	Response: A minority of the target farms have a major enterprise that could benefit
	Reasoning: Farmers have diversified enterprises
Management horizon	Response: About half have a long-term management horizon
	Reasoning: Because the majority live in their villages.
Short term constraints	Response: About half currently have a severe short-term constraint
	Reasoning: Volatile situations in quite a number of areas. Social issues, election related etc. Climate constraints in frost and drought susceptibility

Learnability Characteristics of the Innovation

Trialable	Response: Easily trialable
	Reasoning:
Innovation complexity	Response: Slightly difficult to evaluate effects of use due to complexity
	Reasoning: Trials have been conducted successfully with positive feedbacks from farmers
Observability	Response: Easily observable
	Reasoning: Farmers have good observation skills

Learnability of Population

Advisory support	Response: A minority use a relevant advisor
	Reasoning: Limited accessibility
Group involvement	Response: A minority are involved with a group that discusses new farming
	Reasoning: There are some notable village groups
Relevant existing skills & knowledge	Response: A majority will need new skills and knowledge
	Reasoning: Limited education levels
Innovation awareness	Response: A minority are aware that it has been used or trialled in their local area
	Reasoning: Awareness has been conducted in some areas with accessibility

Relative Advantage of the Innovation

Relative upfront cost of innovation	Response: Minor initial investment
	Reasoning: Farmers will probe the technology
Reversibility of innovation	Response: Moderately difficult to reverse
	Reasoning:
Profit/productivity benefit in years that it is used	Response: Large profit/productivity advantage in years that it is used
	Reasoning:
Future profit/productivity benefit	Response: Large profit/productivity advantage in the future
	Reasoning:
Time until any future profit/productivity benefits are likely to be realised	Response: Immediately
	Reasoning: Within the year.
Local village/community costs & benefits	Response: Large local community/village advantage
	Reasoning:
Time to local village/community benefit	Response: 1 - 2 years
	Reasoning:
Risk exposure	Response: Reduce risk
	Reasoning:

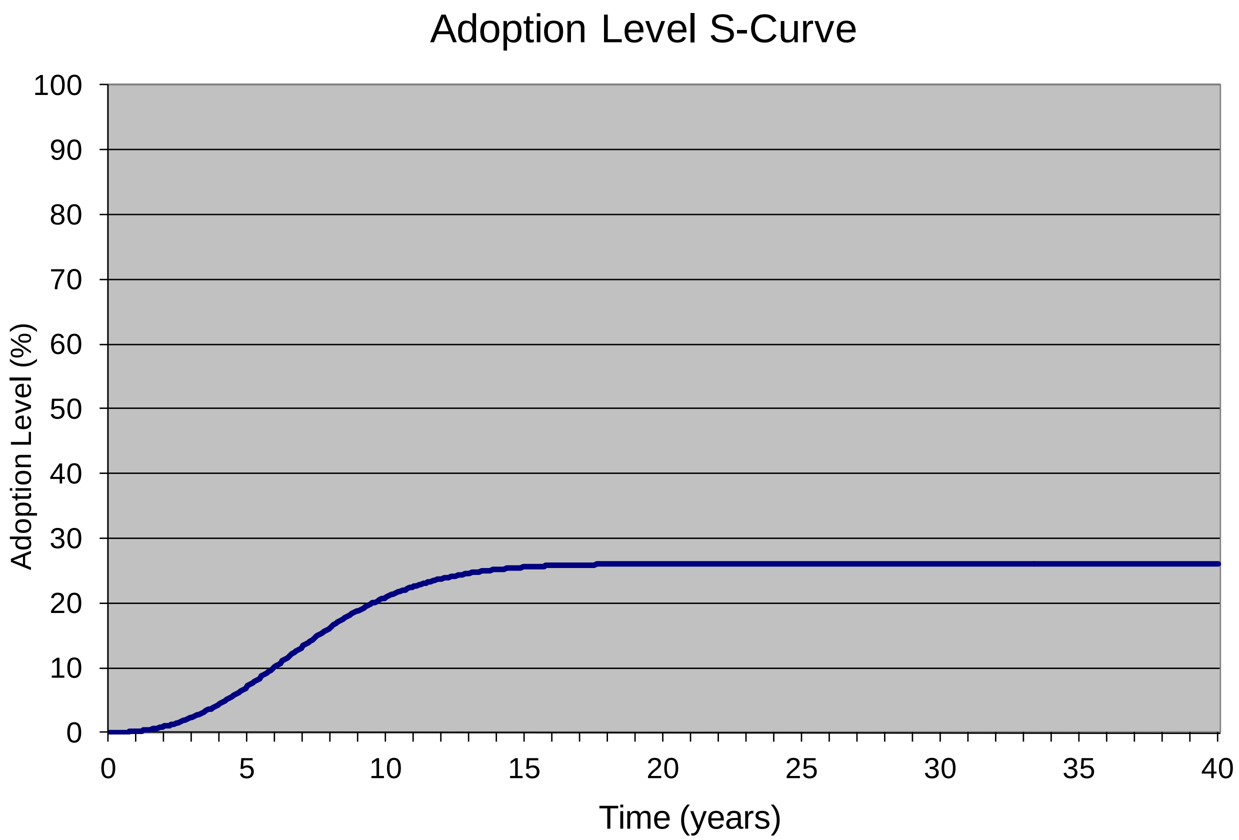
Ease and convenience	Response: Increase ease and convenience
	Reasoning:

Report 3. Low Energy Broiler Concentrate blended with Sweet Potato for Villages in the New Guinea Islands

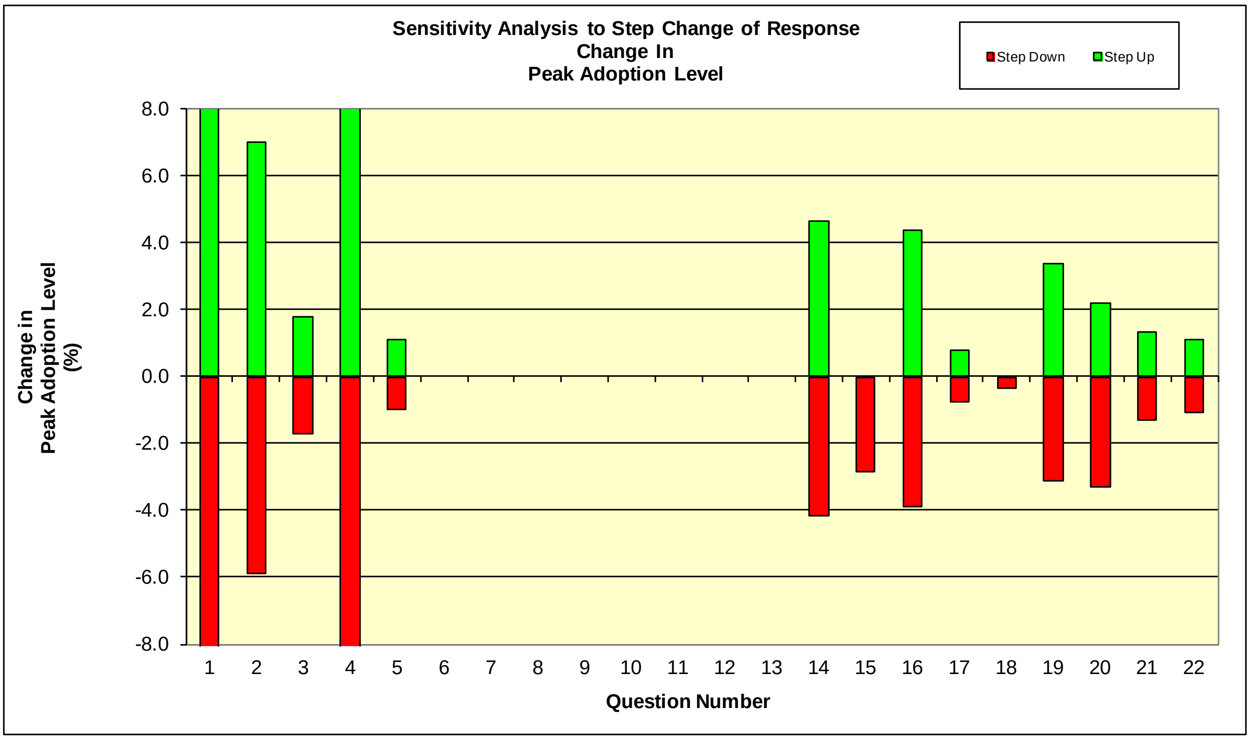
Predicted Adoption Levels

Predicted years to peak adoption	19.8
Predicted peak level of adoption	26%
Year innovation first adopted or expected to be adopted	N/A
Year innovation adoption level measured	N/A
Adoption level in that year	N/A
Predicted adoption level in 5 years from start	7.2%
Predicted adoption level in 10 years from start	21%

Predicted Adoption Curve



Sensitivity Analysis



Information Entered into ADOPT

The above predictions are based on the following information entered into the Adoptability and Diffusion Outcome Prediction Tool.

Relative Advantage for the Population

Profit/productivity orientation	Response: About half have maximising profit/productivity as a strong motivation
	Reasoning: Income generation is an objective and not increasing profits per se; lowering costs.
Local community benefit orientation	Response: A minority have benefits to their local community as a strong motivation
	Reasoning: Most farmers are interested in earning household income from selling broiler birds to the community.
Risk orientation	Response: About half have minimising production risk as a strong motivation
	Reasoning: Island communities are vulnerable to other recent crop failures and poultry diseases so need to diversify and protect their income base.
Enterprise scale	Response: About half of the target farms have a major enterprise that could benefit
	Reasoning: We went with the default.
Management horizon	Response: A minority have a long-term management horizon
	Reasoning: Farmers have cocoa plantations as their best crop produce for earning income.
Short term constraints	Response: A minority currently have a severe short-term constraint
	Reasoning: There are no severe short term constraints.

Learnability Characteristics of the Innovation

Trialable	Response: Easily trialable
	Reasoning: Experience with other farmers and low start up costs
Innovation complexity	Response: Not at all difficult to evaluate effects of use due to complexity
	Reasoning: Using local feeds is already a practice.
Observability	Response: Moderately observable
	Reasoning: Compromise.

Learnability of Population

Advisory support	Response: A minority use a relevant advisor
	Reasoning: Considering the logistics of travel from islands and few numbers of advisors.
Group involvement	Response: A majority are involved with a group that discusses new farming
	Reasoning: There is involvement in cooperatives for other farm groups.
Relevant existing skills & knowledge	Response: A minority will need new skills and knowledge
	Reasoning: Some new skills will be relevant.
Innovation awareness	Response: A majority are aware that it has been used or trailed in their local area
	Reasoning: There is very good awareness through media about agriculture technologies.

Relative Advantage of the Innovation

Relative upfront cost of innovation	Response: Minor initial investment
	Reasoning: Mostly up front spending on equipment and materials compared to continued batch production with lower recurrent spending.
Reversibility of innovation	Response: Very easily reversed
	Reasoning: Standard feed is available.
Profit/productivity benefit in years that it is used	Response: Large profit/productivity advantage in years that it is used
	Reasoning: Reducing cost of feed by 30% is considered a large advantage.
Future profit/productivity benefit	Response: Moderate profit/productivity advantage in the future
	Reasoning: Labour is still required although savings in feed costs are made.
Time until any future profit/productivity benefits are likely to be realised	Response: Immediately
	Reasoning: Within the year.
Local village/community costs & benefits	Response: Moderate local community/village advantage
	Reasoning: There's some.
Time to local village/community benefit	Response: 3 - 5 years

	Reasoning: Improving local protein supply. And other market activity.
Risk exposure	Response: Reduce risk
	Reasoning: Will reduce costs.
Ease and convenience	Response: Decrease ease and convenience
	Reasoning: More labour required.

12.5 Appendix 5: Village farming video script

Video Title: Improving Profitability of Village Broilers in PNG

Time: 5 minutes

Location: Village farms in the Lae district

Production: National Agricultural Research Institute (NARI)

Rationale: Overview on how to improve the profitability of feeding village broiler chickens in PNG

Storyline of Video: A village farmer is shown feeding broiler birds in the traditional manner using commercial feed. An Extension Officer is shown visiting the farm with a bag of concentrate. The officer shows the farmer how to cook local vegetables and mix it in with a concentrate. The audience for the video will be village farmers in PNG and other Pacific Islands and the method they can use to grow broilers using home grown sweet potato or cassava mixed with concentrate.

Audience: Village farmers and Research & Extension officers

Video sections: Lead in → Main title → Introduction → Farmer preparing sweet potato or cassava→ Mixing sweet potato or cassava with concentrate→ Feeding the birds→ Profitability of feeding method→ Summary → Credits

1. Lead in

Images and sounds	Dialogue	Captions	Notes
A village farmer shown feeding birds using commercial feed A village farmer and an extension officer outside the village poultry shed.	Voice Over: Village farmers usually feed a batch of 50 chickens with commercial feed. There is a new method that can be used. Extension Officer Have you heard about the method to feed chickens using concentrate Farmer No, can you tell me more Extension Officer Well, I've got some concentrate feed in my ute; I'll teach you how to feed this to the broilers using the new feeding system.	New method of feeding broilers Use concentrate feed	Village farmer in discussion with the extension officer; the new feeding system is introduced.
			The focus of the video is highlighted.

2. Titles

Images and sounds	Dialogue	Captions	Notes
		Main title: Improving the profitability of feeding village broiler chickens	

3. Introduction

Images and sounds	Dialogue	Captions	Notes
Shows a village farmer buying day old chickens and unloading 6 bags of broiler feed. The extension officer points out how the farmer might try the concentrate feed.	Narrator Under normal circumstances when feeding village poultry you buy 50 day old chicks and 6 bags of broiler feed and they are fed up to about 6 or 7 weeks of age. But there is an alternative feeding system using concentrate feed which has high energy and high protein. This can be used instead of the 6 bags of broiler feed. The farmer can use sweet potato or cassava from his garden and can mix them with the concentrate feed to give to the village broilers.	Use home grown cooked sweet potato or cassava mixed with concentrate	Introduce the concept of feeding with a concentrate and emphasises the importance of reducing feed costs.

4. Farmer preparing sweet potato or cassava

Images and sounds	Dialogue	Captions	Notes
Shows the concentrate being provided by the extension officer. The village farmer is shown getting sweet potato or cassava from his garden, washing, cutting and cooking.	Narrator What you need to do with this new feeding system is to go to your garden or your store where you keep your sweet potato tubers (or cassava) and prepare them by peeling, cutting and cooking. After it is cooked mash the tubers and then it is ready for mixing with the concentrate feed.	Wash, peel and cook sweet potato or cassava	Emphasise the need for peeling, cleaning, cooking and mashing the sweet potato or cassava and use close ups to show how this is done.

5. Mixing cassava or sweet potato with concentrate

Images and sounds	Dialogue	Captions	Notes
This section shows how to mix the concentrate with the cooked vegetables. Image of the 1:4 ratio of concentrate with cooked mash potato or cassava using tins or some other simple volumetric measure	Extension officer After the sweet potato and cassava have been cooked mix it with the concentrate. One part of concentrate feed is mixed with 4 parts of cooked sweet potato. The measurement can be done using a cooking pot or tin. Place one part of the concentrate in a bowl (or tin) and add 4 containers of cooked mash. Mix together by hand ensuring all the mashed sweet potato and or cassava is mixed evenly with the concentrate.	Mix sweet potato or cassava with the concentrate	Description of how sweet potato and cassava is mixed with the concentrate.

6. Feeding the birds

Images and sounds	Dialogue	Captions	Notes
Village farmer feeding his birds with the mixture. Close up shots of the birds feeding and how they are growing quite well on the new feeding system. Concentrate feed stored in a bin with a lid.	Extension officer After you have mixed the sweet potato or cassava with the concentrate go to the feed hopper in your broiler pen. Fill it with the mixture of concentrate and mashed sweet potato or cassava. Allow the birds to eat. Later in the day mix another batch of food, removing the residue. Wet feed will go mouldy if it is allowed to remain in the feeders for two or three days. Clean all the containers used for mixing the feed with the sweet potato.	Feed the birds with the mixture. Clean the feeder to stop the residue going mouldy	Make sure the birds are eating the mix of sweet potato or cassava with the cassava.

7. Profitability of feeding

Images and sounds	Dialogue	Captions	Notes
Birds fed with the normal feeding system vs. birds fed with the sweet potato or cassava.	Narrator By using the sweet potato or cassava feeding system you are saving on at least 30% of the cost of feeding your broiler chickens. You may have to wait a week longer for the birds to reach market weight but the feeding system is so much cheaper that you are still going to make a better profit.	Improve your profit	Describing the improvement in profit

8. Summary

Images and sounds	Dialogue	Captions	Notes
	It is cheaper to feed broilers using cooked sweet potato or cassava mixed with concentrate. The chicken meat tastes better		

9. Credits

Images and sounds	Dialogue	Captions	Notes
		NARI Farmer All Institutions working on project	