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project

Feeding village poultry in Solomon Islands

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prepared by

Dr Phil Glatz
South Australian Research & Development Institute (SARDI)

co-authors/ contributors/ collaborators

Dr Zhihong Miao
Dr Bob Hughes
Tony Jansen
Hearly Aleve
Connelly Sandakabatu

approved by Dr Peter Horne

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ACIAR
GPO Box 1571
Canberra ACT 2601
Australia

Contents

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2 Executive summary

Village poultry in the Solomon Islands (SI) is an important source of dietary protein. In 2003, it was estimated that 22,000 families produced a total of 220,000 birds and 2.64 million eggs a year. This was not sufficient to meet local demand, particularly for village chickens. Increasing the production of eggs and birds is an important goal for meeting the demand and also important for many families to increase their income. The main opportunity for increasing production is to improve the feeding strategy. Improved village chicken production using appropriate feeding will help families to increase production and make available more eggs and meat to improve their dietary intake of protein.

To evaluate rations for village chickens based on locally available feedstuffs a poultry production research unit was built at SICHE in collaboration with Ministry of Agriculture and Lands (MAL) and KGA. This research unit at SICHE enhanced the research capacity, encouraged hands on training of students in poultry production and strengthened the links between collaborators. Four experiments were completed to evaluate the performance of village chickens on diets comprising local feed resources compared to an imported commercial ration. The local diets included various combinations of sorghum, pigeon pea grain and leaves, fresh coconut and cassava, paw paw fruit and leaves, corn, mung beans and fish meal. The results showed that egg production and feed efficiency were lower for birds fed on local diets compared to the important commercial ration. However the cost of imported feed was 5 times higher than the local rations.

To interact with farmers and farmer groups on poultry feeding, a survey was initially carried out to obtain information on current feeding practices used by village farmers. The survey results showed that most farmers thought chickens were easy to care for and a good enterprise for providing cash income and extra food for the family. Other farmers were interested in farming but there was a shortage of village chickens. The problems farmers faced were a lack of available information and training on local chicken management. Many villagers had tried keeping poultry, but lacked knowledge on how to manage them. To disseminate the research information KGA conducted farmer workshops on improved poultry feeding and management with over 100 village participants in Malaita and Western Province. KGA also hosted 30 farmer attachment programs at an upgraded KGA Burns Creek poultry extension facility. The farmers learnt how to feed, house and care for village poultry. The KGA attachment program generated good results with the majority of students putting into practice the feeding and management skills learnt. One page information leaflets on best practice feeding methods for village poultry were made available for village farmers.

In Australia work focused on the role of traditional herbs in organic poultry farming. There is a growing interest in using herbs as a substitute for synthetic antibiotics as a result of the ban in the European Union on the inclusion of antibiotics in poultry diets. Herbs used in the trials were rosemary, thyme, fennel and sage. The performance of the broilers grazing on a commercial diet supplemented with herbs was compared to birds fed a commercial broiler diet. The results showed that grazing on fresh herbs did not significantly influence bird growth, feed conversion or the flavour of the meat but improved the crop weight of the birds. Fresh herbs could be included in a free-range pasture for birds to graze and gives the potential for the organic poultry industry to develop a production system based on herbs as a forage source.

3 Background

The utilization of locally available feed resources (including by-products) to develop cost effective feed formulations was one of the research priorities developed at the South Pacific Islands consultation in December 2003. The need for such research was driven by the high cost of imported poultry feeds. In the SI, there is a vital and viable smallholder egg and chicken meat sector that could benefit financially from improved production methods, and that these farmers are demanding such information from service providers. Improved poultry production is a viable method of increasing income and improving household nutrition. Improved use of local feedstuffs was seen as the best option to improve current low levels of production that are unable to meet the rising demand for eggs and chicken meat.

The SI smallholders operate independently from the commercial layer and broiler industry and produce about 210,000 birds per year, selling eggs and live birds in local markets. The sale of chickens is one of the major sources of income for traditional smallholder farmers, with an estimated 21,000 families (about 40% of the rural population) currently producing eggs and live birds. Birds are fed household food scraps and other locally available feedstuffs. However, the family consumes only about one bird per month. The majority of Solomon Islanders (85%) live in rural regions with poor transport access to the urban areas. Improving the productivity of these village poultry systems would have a significant impact on national production and well-being of at least the rural communities. With an average of 30% of infants underweight due to poor nutrition, the regular addition of eggs, chicken meat combined with more green leafy vegetables in family diets, has the potential to reduce infant malnutrition that has a much wider cost to society. KGA experiences have shown that a production unit of 20-40 village chickens can provide eggs for the family and sale every day and a regular supply of meat birds for consumption or sale. It is anticipated that if feeding strategies can be improved this type of system will be widely adopted.

There is a wide variety of local feed resources available that could be utilized more effectively such as root crops, fruit, forages, bush plants and vines. Farmers in the rural areas are introducing new crops with higher nutritional value for poultry and many of these crops (such as sorghum, mung bean, pigeon pea, sunflower, amaranth and others) are available through the SI Planting Material Network, a national farmers network producing open pollinated seed for rural farmers. This project was conducted to identify effective rations for village birds based on the variety of potential feeds available and to educate farmers on feeding management. These initiatives were planned to support the promotion by KGA of farming village poultry as a means of increasing income and improving protein consumption in the village diet. Women in particular are often responsible for keeping and selling villages chickens, making an important contribution to income for essential family needs.

KGA (a SI non-government organization) was chosen to undertake demonstration and extension activities in the villages. The SARDI Pig and Poultry Production Institute (PPPI) coordinated the project, building on the experiences of establishing a feed testing facility for the smallholder broiler sector in PNG (AS2/2001/077). The objective was to encourage smallholder farmers to use more suitable rations for their birds, and stimulate an increase in the number of village layers, increasing income and greater consumption of eggs and meat by village families.

At the time of commencing the project, there were no research facilities in the SI for testing diet formulations. Establishment of such a facility was seen as essential for the evaluation of the production performance of local village layers. The aim was to

test rations in the SI specific to areas where the feeds are available for layers village poultry.

In Australia, demand is increasing for organic egg and broiler chickens farmed in alternative less intensive systems of production. The organic sector is showing interest in using traditional herbs to overcome some of the poultry health issues that arise in these systems of farming. However, information on palatability and nutritional value of these plants is scant. The Australian component of the project concentrated on aspects of the organic system that have some commonality with some of the smallholder forage sources available in the SI.

4 Objectives

1. To develop rations for village-based layer and meat birds based on locally available feedstuffs (through staff training and the establishment of a research facilities to enable sound scientific evaluation of rations formulated for village layers and meat birds; and the conduct of feeding trials to determine the performance of village layers and meat birds fed rations formulated by using local available feed ingredients).
2. To interact with farmers and farmer groups to evaluate, disseminate and communicate the value of rations based on local feedstuffs (including the conduct of a baseline study of current poultry feeding strategies and productivity; training of provincial extension agents, NGO staff and farmer leaders in effective farmer communication strategies and poultry management; conduct of demonstration trials on-farm, at Farmer Schools and Rural Training Centres; and production and distribution of information in a variety of appropriate forms and manners to stakeholders in the poultry sector).
3. In Australia, to evaluate the nutritional value and palatability of innovative feedstuffs in organic poultry production and communicate information to industry (including evaluation of performance of free-range layers to the inclusion of traditional herbs in the diet and communication of information to the industry).

5 Methodology

5.1 Establish a production research unit to enable sound scientific evaluation of rations formulated for village layers and meat birds

5.1.1 Design of the facility

Collaborators from the SI visited colleagues in Lae, PNG to obtain ideas on the type of research facility to build in the SI. Tony Jansen (KGA) and Nick Nonga (MAL) visited NARI in Lae in May 2005 to view facilities and discuss the poultry extension program with the Salvation Army in Kainantu, PNG. This was followed by a visit to Roseworthy to view PPPI facilities, visit commercial farms and discuss the proposed SI research facility and the village survey. Then in June 2005, Phil Glatz and Bob Hughes from SARDI visited the SI, met with SI staff to discuss location and design of the poultry production unit. SICHE was selected as the site for poultry research facility by the research collaborators. The poultry research facilities (made from local materials) were set up to conduct village poultry nutrition and production research.

In 2006, MAL had considerable difficulty obtaining village chickens for the feeding trails. Therefore MAL and SICHE decided to build a poultry breeding facility to produce fertile eggs for incubation and hatching. The breeding unit was utilised to supply village chickens for the research trials and has the capacity to supply birds to farmers who lost their birds during the Tsunami.

5.1.2 Training of scientists

Joseph Wahananiu (MAL) and Hilda Karani (KGA) undertook training at the PPPI from 29 July-13 August 2006 in the feed evaluation unit. The training included working with PPPI staff to carry out daily husbandry activities associated with a feed trial, assisting with bird dissections, preparing samples for storage and visiting commercial farms where on-farm research trials were being conducted.

Mr Barney Keqa was awarded a John Allwright Fellowship to undertake a master degree by course work at University of New England in Australia including a project to evaluate the strains of village chickens available in the SI.

5.1.3 Scientific protocols

Bob Hughes and Derek Schultz from SARDI visited the SI during September and October 2005 to assist MAL and SICHE with the set up of the research facility and to advise KGA on quality assurance protocols for demonstration trials. Staff at the KGA's Burns Creek facility were given instruction on record keeping, other documentation and analysis of the trial data on choice feeding and preliminary "best guess" diet mixes based on locally grown ingredients used by villagers.

5.1.4 Onsite development and operation of the protocols of the SICHE facility

Assistance was also provided to MAL during the final stages of construction and set-up of the new research facility at the SICHE campus. MAL staff were also provided the procedures for record keeping, documentation and analysis of experimental data on the nutritive value of locally grown feed ingredients.

5.1.5 Onsite development and operation of the KGA village demonstration unit

The demonstration facility at KGA's poultry training facilities was upgraded to enable village birds to be reared at these sites to supply stock to the SICHE research facility. The facilities at KGA were also used as a demonstration and training site for village farmers.

5.1.6 Training to run a village poultry unit

Derek Schultz from SARDI conducted training at KGA to assist staff to develop protocols for running demonstration trials on village farms.

5.2 Conduct on-station feeding trials to determine the performance of village layers and meat birds fed rations formulated from PNG and other nutritional data

5.2.1 Nutrition fact sheets

Fact sheets for local feed ingredients in SI were developed by SARDI. 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 the internet, journals, feed ingredient tables and books and is presented in Appendix 1.

5.2.2 Rations for village layers and XL spreadsheets

A simple Microsoft XL feed formulation spreadsheet was developed by SARDI to formulate 4 layer diets for evaluation in village chickens.

- Diet 1: corn (44%), fresh grated cassava (6.3%), ripe pawpaw (5.4%), mung beans (30%), fishmeal (6%), lime (8%) and salt (0.3%).
- Diet 2: Pigeon pea (35%), paw paw fruit (5%), mung beans (37%), fresh grated coconut (7.7%), fresh grated cassava (8%), lime (7%) and salt (0.3%).
- Diet 3: pigeon pea (9%), corn (5%), paw paw fruit (3%), sorghum (35%), fresh grated cassava (5%), fishmeal (7%), mung beans (28.7%), lime (7%) and salt (0.3%).
- Diet 4: pigeon pea (8%); sorghum (37%), fish meal (15%),fresh leucaena leaf (5%), fresh grated sweet potato (7%), fresh sweet potato vines (5%), ripe bananas (10%), fresh chilli (2%), fresh clover (3%) and lime (8%).

5.2.3 Experimental design

A completely randomised design was used for the feeding trials in the poultry unit at SICHE. Each trial comprised 4 replicates of a control commercial layer diet (as the gold standard control) and 4 replicates of the local feed diet. Experimental diets were formulated according to nutrient requirement of hens recommended by NRC (1994). Feeding trials lasted for 9 weeks.

5.2.4 Birds and housing

A total of 64 local hens were used for each trial. The birds were obtained from KGA, local communities with different ages. Later trial used birds from the SICHE breeding

facility. Eight birds were allocated at random into each pen with four replications for each treatment.

5.2.5 Diet preparation

Whole seeds of corn and mung bean were fed to birds. This was due to the lack of grinding equipment and soaking facilities. The cassava and pawpaw were fed fresh after mixing with other components of the diets. Birds were fed twice a day.

5.2.6 Parameters measured

Bird liveweight was recorded weekly. Egg weight, number of eggs laid, feed intake and feed residue were recorded daily.

5.2.7 Statistical analysis

The treatment effects were assessed with ANOVA in Systat software (Wilkinson, 1996). Bonferroni's post hoc was used to separate means only if significant main effects were detected by analysis of variance. Bonferroni's post hoc test is a multiple comparison test based on Student's t statistic and adjusts the observed significance level when multiple comparisons are made.

5.3 Interact with farmers and farmer groups to evaluate, disseminate and communicate the value of rations based on local feedstuffs

5.3.1 Baseline survey

The baseline survey was conducted to obtain information on current feeding practices that were being used, consumption of eggs and meat and income being generated from village poultry enterprises in the SI.

5.3.2 Questionnaire

The survey questions were aimed to collect information about ownership, size of village poultry operations, reasons for keeping village chickens, aspects of management and disease, marketing and social problems, farmer attitudes to keeping of village chickens, main problems faced, types of assistance farmers needed and farmers future intentions regarding village poultry production.

A survey questionnaire, that was used in PNG to obtain information from smallholder farmers on chicken feeding practices in project LPS/2001/077 was used as the basis for the survey questions (attached in the appendix 2) in the SI. Modifications of the questions were made by the project team to cover village poultry practices in the SI. The survey questionnaire was also developed through a series of meetings between personnel from SARDI, MAL and KGA. The survey form was tested in the field at Avuavu (Guadalcanal Province) during the first field trip and some changes to the survey questions were made.

5.3.3 Selection of farmers

Three village farm sites were chosen which were in the same area as KGA farmer schools that had established models of village poultry production. Some training activities by KGA were already underway in these areas and so the results may not represent the 'average' rural area. The survey covered the villages of Veranoli, Namoku, Haemarao, Moku, Botuvua, Lualua, Bubuvua, Haimarao, Pubuvua, Vera Chiria, Boliu, Salakulikuli, Haemaro and Vatuli in Guadalcanal Province; Sauboro,

Sausama, Tanahuka, Nusamaheri, Tanhuka, Nusamahiri, Tanuhuka, Damidami and Nusamari in Western Province and Fuliauladoa, Gwunafiu, Busurata, Lalita, Bialau and Kwalo in Malaita Province. During October and November 2005 MAL and KGA staff interviewed up to 90 village poultry farmers in the Malaita, Guadalcanal and Western Provinces.

5.3.4 Statistical analyses

During the interviews, farmers who had not kept village chickens in the last 12 months and those who were only planning or preparing to go into chicken production were required to respond to certain questions. Those who kept village chickens in the last 12 months and/or were currently keeping village chickens had to respond to a greater number of questions to provide more detailed information on their chicken operation. The answers were grouped into categories and given a score and analysed to determine if there were any statistically significant differences in the answers provided. The differences in categories within a question were assessed with ANOVA in Systat software (Wilkinson, 1996). Bonferroni's post hoc was used to separate means only if significant main effects were detected by analysis of variance. Bonferroni's post hoc test is a multiple comparison test based on Student's t statistics and adjusts the observed significance level when multiple comparisons are made.

5.4 Train provincial extension agents, NGO staff and farmer leaders in effective farmer communication strategies and poultry management

5.4.1 Extension training

Four farmer schools were selected to conduct farmer trials and demonstrate research results to farmers. Farmer schools inputs provided by this project included;

- Training attachments at Burns Creek for lead farmers
- Budgets for materials for establishing model farms
- Visits to village farms by KGA and MAL staff

5.4.2 Farmer advisory committee

A farmer's research advisory committee was established in 2007 which gave advice on ingredients to test in the SICHE trials. The committee suggested some sharing activities and on farm trials for lead farmers. Some of the suggestions included using more readily available feeds such as root crops and termites.

5.5 Demonstration trials on-farm, at Farmer Schools and Rural Training Centres

The extension activities focused on training and demonstrating models for improving poultry management. KGA Burns Creek was used as the demonstration centre to conduct the trials. The facilities of KGA were upgraded including an improved breeding facility and better management of poultry for training, trials and multiplication. KGA technician (Hilda Karani) improved her technical, research and training skills with support from SARDI training and close mentoring by Joseph Wahananiu. Bird capacity at KGA was expanded to 100 chickens. KGA also provided seed for growing feed at SICHE, provided chickens, logistics to purchase chickens from villages, shared equipment for research trials; and also provided seed stock for

farmers (sorghum, mung bean, cowpea, Japanese kabis, pigeon pea, long beans and clover).

5.5.1 Diets

The diet used in demonstration trials at KGA comprised sorghum (30%); pigeon pea (30%), fresh coconut (20%), pigeon pea leaves (10%), and paw paw leaves (10%). Other demonstration trials at KGA included; 1) comparing mixed feed with free choice feeding, 2) a commercial ration diluted with a local diet, and 3) using maggots as feed for local chickens.

5.5.2 Measurements

The numbers of egg laid and egg weight were recorded for each demonstration trial.

5.6 Evaluate the nutritional value and palatability of herbs

5.6.1 Establish plots of herbs

Pots of the herbs, rosemary, thyme, sage and fennel, were purchased from a nursery in South Australia and kept in a glass house until they had grown to a height of 60cm (rosemary and thyme) or 10cm (sage and fennel).

5.6.2 Rations for meat birds

There were two rations provided to birds. Birds on control treatment were fed a commercial broiler grower diet. The birds on the herb treatments were fed on the control diet, but were also allowed to graze on fresh herbs-rosemary and thyme in the first trial and sage and fennel in the second trial.

5.6.3 Experimental design

A completely randomised design was used for these trails. Chickens were randomly allocated into 6 groups of 20 birds. In trial 1 there were 3 treatments (control, rosemary and thyme) with each being replicated 2 times. Each treatment had 2 replicates with 20 birds in each replicate. In trial 2 there were also 3 treatments (control, sage and fennel) with each being replicated 2 times. Each treatment had 2 replicates with 20 birds in each replicate.

5.6.4 Birds and housing

Trial 1: A total of 120 chickens (Cobb broiler strain) of mixed sex were raised from hatch in floor pens under a brooder at the PPPI poultry unit until 17 days of age. They were then transferred to an eco-shelter (3m x 3m) located in the centre of a 4 ha paddock at the PPPI free range facility. The eco-shelter was made up of light steel framework covered by a high ultra violet protective shade cloth. Curtains were fitted on the 4 sides of the shelter to enable manual manipulation of the ventilation. Birds were provided feeders and drinkers in the shelter but no artificial light. The eco-shelter had 6 internal pens of equal size (1.5 square meters).

Trial 2: A total of 120 chickens (Cobb broiler strain) of mixed sex were raised from hatch in floor pens under a brooder at the PPPI unit until 23 days of age. They were then transferred to an eco-shelter (3m x 3m) located in the centre of a 4 ha paddock. It was made up of light steel framework covered by a high ultra violet protective shade cloth. Curtains were fitted on the 4 sides of the shelter to enable manual manipulation of the ventilation. Birds were provided feeders and drinkers in the

shelter but no artificial light. The eco-shelter had 6 internal pens of equal size (1.5 square meters).

5.6.5 Feeding

The birds were fed daily in the morning for each trial. Pots of herbs were placed into each pen every morning and then removed every evening during the experimental period for each trial. Three pots of each herb were placed in each pen for birds to graze on. Pots were weighed before and after grazing to measure the daily intake of herbs. One pot of each herb (not grazed by chickens) was used as a control to estimate growth and water loss from the pot.

5.6.6 Parameters measured

Body weight and feed intake were recorded. At the end of the experiment, 4 birds from each treatment were weighed and then euthanased with 0.5 ml of pentobarbitone injected into the brachial vein. The crop was dissected and crop samples collected. Wet and dry weight of crop samples (to nearest 0.01g) were obtained and then stored in plastic cups, sealed in plastic bags, and stored at -4°C to prevent digestion of the crop contents. The low magnification (10x) of an Olympus microscope was used to classify the crop contents. A pair of forceps was used to tease apart the contents to identify the larger materials such as commercial feed, herbs and other obvious materials. At a higher magnification (20x) the same procedure was carried out for the smaller components. The materials left were categorised as other. The wet and dry (oven dry at 40°C for 24 hours) weight of crop tissue was determined.

The chemical composition and mineral contents of herbs were determined. Crude protein, acid detergent fibre, neutral detergent fibre and crude fibre in leaf and stem of herbs were determined using methods developed by the ANKOM company at the PPPI Nutrition Laboratory). The N content was determined using Total Combustion Gas Chromatography (Dumas Method) on the Carlo Erba Nitrogen Analyser. Mineral content was determined using the Spectro CIROS radial view instrument after nitric/hydrochloric acid digestion.

5.6.7 Statistical analysis

The treatment effects were assessed with ANOVA in Systat software (Wilkinson, 1996). Bonferroni's post hoc was used to separate means only if significant main effects were detected by analysis of variance. Bonferroni's post hoc test is a multiple comparison test based on Student's t statistic and adjusts the observed significance level when multiple comparisons are made.

6 Achievements against activities and outputs/milestones

Objective 1: To develop rations for village-based layer and meat birds based on locally available feedstuffs.

no.	activity	outputs/ milestones	completion date	comments
1.1	Establish a production unit to enable sound scientific evaluation of rations formulated for village layers (P).			
1.1.1	Train SI staff in the management of the facility (A)	Staff training completed	08/05	SI staff trained at SARDI included Joseph Wahananiu and Hilda Karani who were given instruction in the SI by SARDI staff on QA protocols for research and demonstration trials, including procedures for record keeping, documentation and analysis of trial data. Both staff set up the poultry demonstration facility at KGA.
1.1.2	Infrastructure - test runs, design, construction, acquire equipment (P)	Research facility producing sound scientific results and quality assured results	10/05	Assistance was provided to MAL during the final stages of construction and set-up of the new research facility at the SICHE campus at Kukum. This research facility has been used for teaching, feeding and demonstration trials. A breeding unit was also established at SICHE.
1.1.3	Testing the facility and protocols (P)	Trial protocols were understood by local staff and procedures established (P)	08/06	SARDI provided assistance in developing trial protocols. MAL staff were provided the procedures for record keeping, documentation and analysis of experimental data. Staff at the KGA's Burns Creek was given instruction on record keeping, other documentation and analysis of the demonstration trials on choice feeding and preliminary 'best guess' diet mixes based on locally grown ingredients used by villagers.
1.1.4	Develop written protocols and procedures (P)	Protocol documentation prepared (P)	08/05	Written protocols were distributed to all participants.
1.2	Conduct on-station feeding trials to determine the performance of village layers and meat birds fed rations formulated from PNG and other nutritional data.			
1.2.1	Develop rations from PNG data (A)	Rations for village chickens developed	10/05	It is clear that feed costs can be reduced 5 fold by making greater us of local feed ingredients.
1.2.2	The production performance of village layers and meat birds on rations assessed (P)	Bird performance documented (P). Best rations validated (P).	03/07-12/08	Lower production was found for rations formulated using local feed ingredients compared to imported commercial rations. However, the cost of the local feed is cheaper than the commercial feed. Therefore using local available feed will increase the profit for village chicken farmers.

P = partner country, A = Australia

Objective 2: To interact with farmers and farmer groups to evaluate, disseminate and communicate the value of rations based on local feedstuffs

no.	activity	outputs/ milestones	completion date	comments
2.1	Extension and on farm evaluation (P)			
2.1.1	Conduct a baseline study of current poultry feeding strategies and productivity (P)	Feeding practices in villages determined (P). Data on current local feeds, benchmark production, sales and use of poultry products (P)	11/05	This survey provided information on SI village poultry production including housing, management and feeding. A research paper has been submitted to 'Tropical Animal Health and Production' and accepted for publication.
2.1.2	Train provincial extension agents, NGO's staff and farmer leaders in effective farmer communication strategies and poultry management (P)	Feeding practices in villages determined (P). Information and technology were delivered to the local poultry community. This included training courses, feeding practices in village, on-farm demonstration trials were completed and extension materials were distributed (P)	11/05	Farmer attachments and a demonstration trial were hosted by KGA and also at farmer schools. Fact sheets on a range of SI feed ingredients were distributed to all collaborators. Farmers held advisory committee meetings at the Tanagai Community Based Training Centre
2.1.3	Carry out demonstration trials on-farm, at Farmer School and Rural Training Centres (P)	Establish demonstration activities with smallholder farmers (P).	09/07	The demonstration trials compared mixed vs free choice, commercial vs local feed and an alternative protein source (maggots). KGA also demonstrated farm models in Gwaunafiu, Turusuala, Sausama, Tanagai farm schools. Farm attachments were conducted and young farmers were trained at farmer schools (6 in Western Province). KGA and MAL staff worked on other rural training centres with less formal involvement in the project: eg Vatu (Guadalcanal), Kuzi (Western Province) and Sepi (Malaita). Farmer workshops in Guadalcanal (2), in Malaita (3), Makira (2), and Western Province (2)
2.1.4	Follow studies of feeding practices (P)	Change in feeding practices determined (P)	01/07	Many of the farmers who participated in the attachment program at KGA implemented the feed strategies on their farms.
2.1.5	Produce and distribute information in a variety of appropriate forms and manners to stakeholders in the poultry sector (P)	Extension materials distributed (P)	12/08	Information on theory and practical management of village poultry was distributed to farmers via fact sheets, newsletters, radio and handbooks.

P = partner country, A = Australia

Objective 3: To evaluate the nutritional value and palatability of innovative feedstuffs in organic poultry production and communicate information to industry

no.	activity	outputs/ milestones	completion date	comments
3.1	Herb nutritive value assessed (A)	Spreadsheet of herb nutritive values documented (A)	04/05	Nutritional information was documented for herbs
3.2	Production responses of birds to inclusion of herbs in the diet (A)	Protein, fibre and mineral content of herbs (Rosemary, Thyme, Fennel and Sage) were determined (A). The production performance of birds grazing on herbs was determined (A)	09/06	The trials showed that meat birds will forage on herbs resulting in changes in weight to segments of the alimentary tract which may influence transit time and digestibility of feed in the gut. However, the health aspect of foraging on herbs needs further investigation particularly the effect on the profile of gut bacteria. Fresh herbs can be included in a free-range pasture for meat birds without impacting on performance.
3.3	Communication of information to organic industry (A)	SARDI free range Website upgraded with new information and factsheets developed for distribution from Roseworthy Farm Information Centre (RFIC). Meetings held with key farmers to transfer information (A).	07/08	At the completion of all the trials the SARDI website was upgraded with information on the use of herbs in organic free-range systems A paper was presented at the 23rd World's Poultry Congress in Brisbane and an abstract of the paper was published in the World's Poultry Science Journal. A full paper on the herb trial was published by "FeedInfo" on the internet.

P = partner country, A = Australia

7 Key results and discussion

To evaluate the rations formulated using local feed ingredients for village chickens a poultry production research unit and a breeding unit were built at SICHE, which also enhanced research capacity, encouraged training of students in poultry production and further strengthened the links between collaborators. The poultry research facilities at SICHE has also enabled students to learn research procedures and get hands on experience in poultry feeding, management, bird handling and data recording. Land at SICHE was also used to plant crops for use as different feed resources in village poultry rations. A simple Microsoft Excel spreadsheet was used to develop 4 village chicken rations for evaluation. Main ingredients were sorghum, pigeon pea, fresh coconut, pigeon pea leaves, paw paw fruits and leaves, corn, mung beans, fish meal, fresh cassava. The feed trials showed that egg production, body weight and egg weight were lower in birds fed the local rations compared to an imported commercial ration. However the cost of imported feed was 5 times greater than the cost of local grown feed. These trials also encouraged farmers to use their own available feedstuff to feed their chickens, obtain reasonable production and improve income.

The aim of the survey was to obtain basic information on the current feeding practices and farmer attitudes on village poultry production and to assess the possibility of using local feed to reduce feed cost and increase farm profitability. Prior to the research results being distributed, farmers thought the most important income was from garden products, less important was the income from chicken and egg production. Garden products were also important food sources and again chicken and eggs were less important as food sources. Over 62% of surveyed farmers kept chickens and 83% of surveyed farmers would like to keep chickens. The purposes for keeping birds were for cash income, home consumption, social status and roosters for fighting. The main reasons for not keeping chickens was a lack of knowledge and resources such as no access to feed and birds, finance and market and problems caused by predators. The respondents reported needing better access to feed, chicks and markets, credit, fencing, housing and controlling theft and predators before they would start keeping chickens. Most of the materials for building chicken houses were collected at no cost from the forest.

The main sources of feed for chickens were fresh coconut, food scraps, white ants, copra meal and fish meal. Chickens also obtained feed by foraging around the village. The main methods for preparing feed was by scraping and cutting. Most of the farmers (64%) did not provide water for birds and assumed birds could source water themselves. Only 26% of surveyed farmers transported feed. Most of farmers knew when chickens were sick by their appearance (37%), or when they were not eating (26%). Most of the work was done by family members including parents, children and grandparents. Family members also made the decision on when to sell birds and price. Most of the farmers faced social problems (87%), including demands for gifts, jealousy, theft, diseases and predators. The main assistance needed for village chicken production was feeding management (76%), others included housing and fencing, feed types, disease recognition and treatments and more information on practical aspects. All farmers would like extension officers to visit them. The majority of farmers thought keeping village hens was good for income. A few farmers thought chickens created a mess around the village, damaged crops and were difficult to manage. In the future most farmers would like to expand their village poultry operation to increase income and food supply.

The extension of the results of the project was undertaken by KGA through their farmer schools in Gwaunafiu, Turusuala, Sausama and Tanagai. Young farmers

were trained through attachments at the farmer schools-Vatu (Guadalcanal), Kuzi (Western province) and Sepi (Malaita). Workshops were conducted by KGA and MAL staff over 3 days with a mixture of theory and practice provided to the students. One-page information leaflets on best practice feeding methods for village poultry were circulated to all villagers attending the training. The leaflets show pictures of the feed ingredients, how they are prepared, amount of each ingredient to include in the diet based on using a coconut to measure volume and how the diet is fed to birds. The KGA poultry trainer's handbook and farmer booklet, including information generated from the project, were distributed through the KGA village farmer network. These extension workshops provided large amounts of information to farmers on poultry feeding and management. Some farmers established their own poultry farms after training and shared the information with other farmers.

It is clear that many farmers in the SI are keen to use the results of the trials and start keeping village chickens, commercial layers and meat chickens. There is need to develop an awareness program and to educate more rural people about the benefits of keeping chickens. The Women in Agriculture group are keen to obtain more support for their agriculture activities. However the personnel involved in the smallholder and the semi commercial feed industry must develop the expertise to manufacture the rations. The majority of smallholder farmers lack basic nutritional knowledge of formulating practical, nutritionally adequate rations from locally available ingredients. Many also lack the necessary skills and experience to make high quality farm-made feeds suitable for feeding poultry. Knowledge on the infrastructure required to produce and store dried feeds and ingredients is also limited. It was recommended that feed milling equipment be purchased that can produce about 5-10 tonne feed per week in a semi commercial operation. This amount would be sufficient to feed about 5,000-10,000 village hens per week. In addition it was suggested that hand operated equipment suitable for individual village farmers be established to feed up to 50 village chickens/day.

In Australia work focused on the role of traditional herbs in free range organic poultry farming. There is a growing interest in using herbs as a substitute for synthetic antibiotics in chicken rations as a result of the ban in European Union on the inclusion of antibiotics. Broilers were given access to the herbs Rosemary, Thyme, Fennel and Sage in feeding trials at Roseworthy Campus. Broilers housed in eco-shelters were fed broiler grower diets (control) and their performance compared to birds fed the control diet but also allowed to graze on fresh herbs. Supplementing fresh herbs did not significantly affect bird performance. However the dry crop tissue weight of birds grazing on thyme was heavier than the birds on the control and the rosemary treatment. The weight of crop tissue and crop content (wet and dry) were also heavier for fennel and sage treatments. This could indicate that herbs enhanced the development of the crop probably due the fibre content of the herbs (Tabook et al., 2006). This may slow down the feed passage rate through the crop and enhance digestibility (Hetland et al., 2004). There is a common perception that birds grazing on herbs would produce meat with a better taste. However the results showed that meat from the rosemary treatment was similar to the control while flavour, colour and texture of meat from thyme treatment was poorer than the control birds. These finding support recent work that organic meat is not as tastier as birds grown under commercial conditions (http://www.worldpoultry.net/news/id2205-51210/organic_chickens_have_less_flavour.html).

7.1 Establish a production research unit to enable sound scientific evaluation of rations formulated for village layers and meat birds

7.1.1 Poultry research facility

Poultry research and breeding facilities (Figure 1 and Figure 2) were established at SICHE. These facilities have enabled high quality poultry nutrition research to be undertaken and sound research results to be achieved. These facilities were crucial to the SI as they have enable MAL, SICHE and KGA to resume R&D activities and to assist with developing livestock research capacity in the SI. The facilities are sited above the ground to avoid flood damage. The facility comprised 16 pens with perches, nest boxes, drinkers and feeders which enable adequate replication of dietary experiments to be conducted both for meat birds and layers. These facilities can also be used for student training to strengthen their practical skills and increase their knowledge of poultry nutrition and breeding.

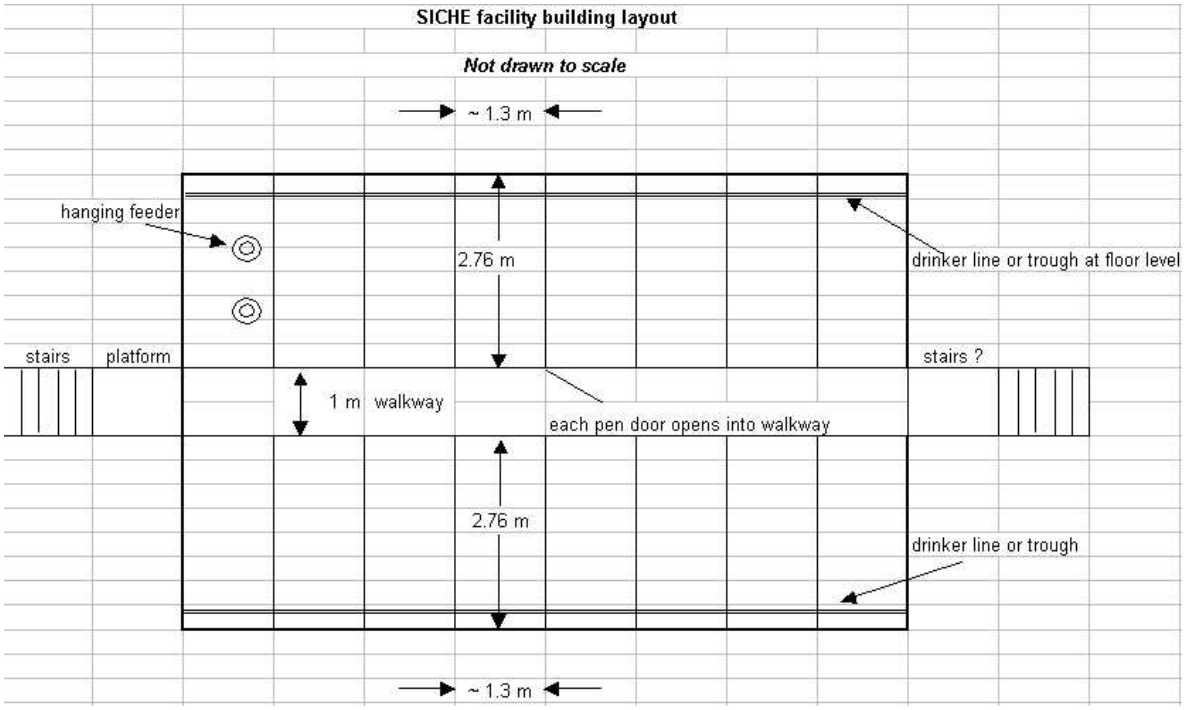

Figure 1. SICHE research facility-plan view of layout

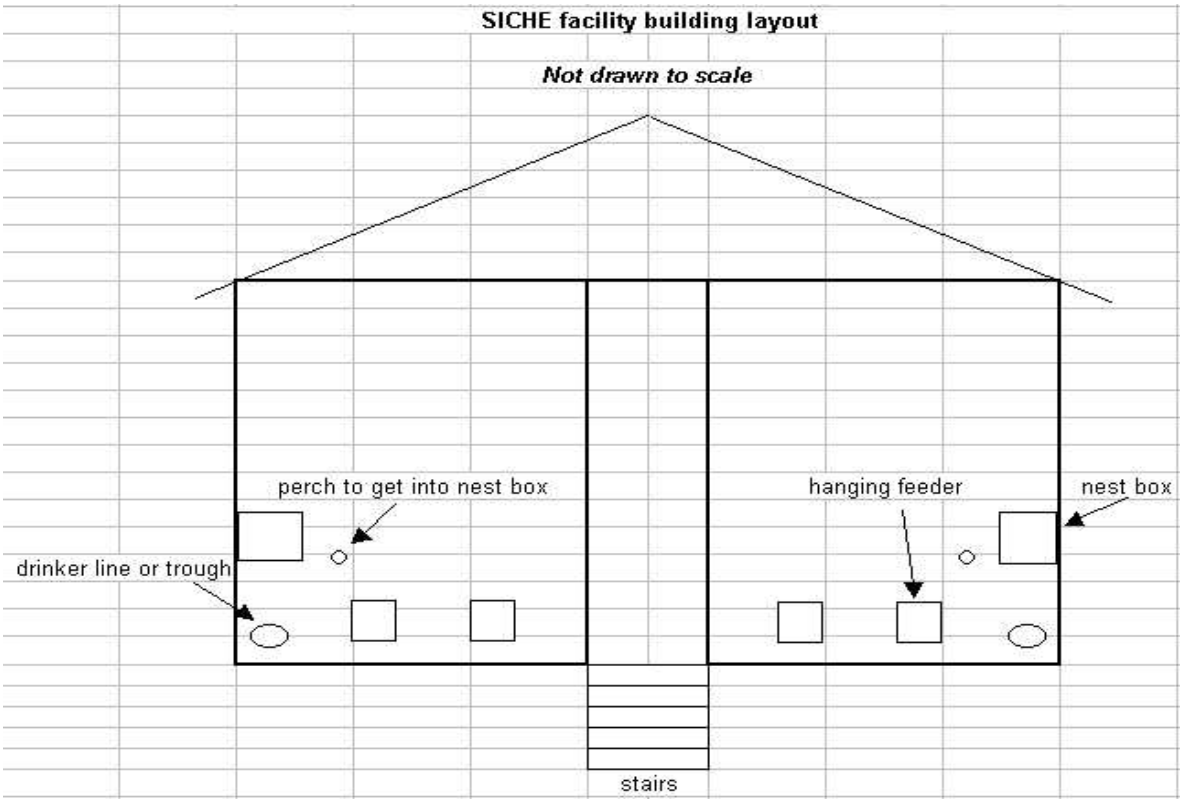

Figure 2. SICHE research facility-side view of layout

7.1.2 Training of scientists and students

Joseph Wahananiu (MAL) and Hilda Karani (KGA) undertook training at the PPPI in the feed evaluation unit. The training included working with PPPI staff carrying out daily husbandry activities associated with a feed trial, assisting with bird dissections, preparing samples for storage and visiting commercial farms where on-farm research trials were being conducted. In addition, Joseph Wahananiu and Hilda Karani received instruction at the SICHE research site by SARDI staff on QA protocols for research and demonstration trials, including procedures for record keeping, documentation and analysis of trial data. The knowledge developed by SICHE, MAL and KGA staff from building the SICHE facility has enabled them to complete an upgrade of the KGA demonstration facilities. Barney Kequa was awarded a JAF Fellowship and commenced a course work master's degree in February 2008. His project focuses on identifying phylogenetic characteristics of village poultry in the SI. This work is likely to lead to greater recognition of the importance of village chickens in village farming systems in the Pacific.

7.1.3 Scientific protocols

Protocols for running poultry feeding trials were provided to staff at SICHE and KGA for running the research and demonstration trials. The information provided details on experimental design, set up of pens, feed mixing, data recording and analysis.

7.1.4 Onsite development and operation of the protocols of the SICHE facility

MAL, SICHE and KGA staff were assisted on site by SARDI staff on how to apply the research protocols. This included extensive training in Australia prior to the established of the SICHE R&D facilities.

7.1.5 Onsite development and operation of the KGA village demonstration unit

One of the significant achievements in the project after training at the PPPI and SICHE site, MAL and KGA staff built a poultry demonstration unit at KGA which was based on the SICHE poultry research unit. The breeding and management of poultry at KGA facilities were outstanding in the year following the renovation compared to previous year. The improvements in performance noted were also due to staff developing sound operating protocols for the demonstration trials. Staff received hands-on training from SARDI staff and understood the demonstration protocols.

The KGA demonstration centre also comprised a village poultry unit. KGA staff were trained by SARDI staff in how to run poultry feeding trials using the rations developed during the project.

7.2 Conduct on-station feeding trials to determine the performance of village layers and meat birds fed rations formulated from PNG and other nutritional data

7.2.1 Nutrition fact sheets

The feed ingredient fact sheets were developed by SARDI as a general guideline for the use of feed ingredients for poultry and pigs in the SI. The feed ingredients included 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, amaranth, sunflower meal, pigeon pea, fresh coconut, mung bean, cow pea, cabbage, pigeon pea leaves, pawpaw leaves and fruit, pigeon pea, chilli and clover. The fact sheets contained the name, general description, chemical composition, nutritive value and anti-nutritional factors for each ingredient. The fact sheet also provided guidelines on the use of these ingredients in pig and poultry diets. Individual feed ingredients are listed in Appendix 1.

7.2.2 Trial results

The feed intake and egg production from birds fed the 4 diets formulated using local available feed ingredients for individual trial are shown in Figures 3-10. The overall trial results are shown in Figures 11-15. The results showed that the production of village layers fed diets with local ingredients is lower compared to commercial diets. However, the cost of using local feed is considerably less. Trial results are listed in Appendix 3.

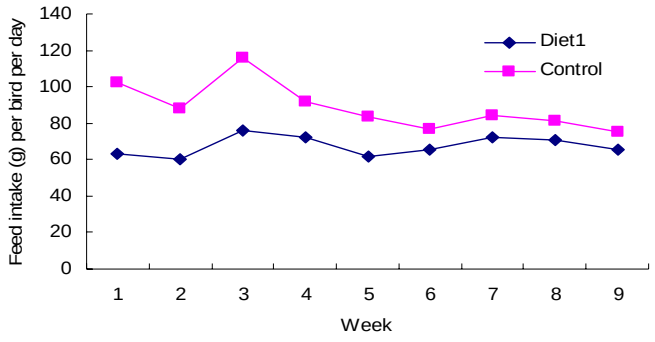

Figure 3. The feed intake (g/d/bird) for birds fed diet 1 compared to birds fed the imported commercial layer diet (control).

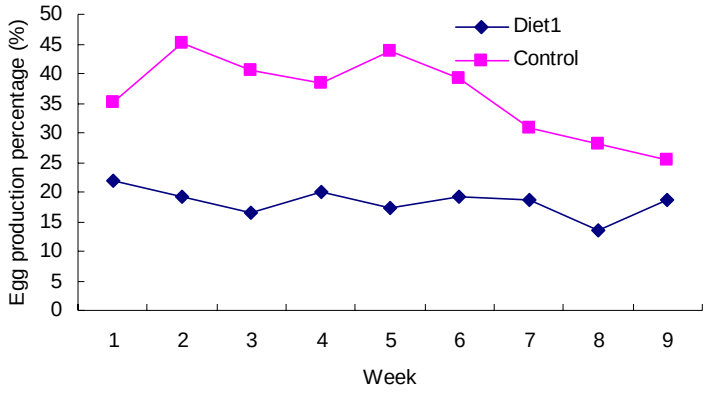

Figure 4. The egg production percentage (%) for birds fed diet 2 compared to birds fed the imported commercial layer diet (control).

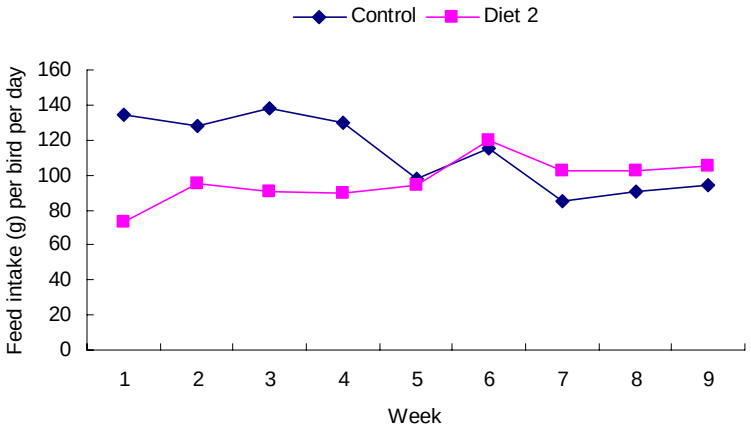

Figure 5. The feed intake (g/d/bird) for birds fed diet 1 compared to birds fed the imported commercial layer diet (control).

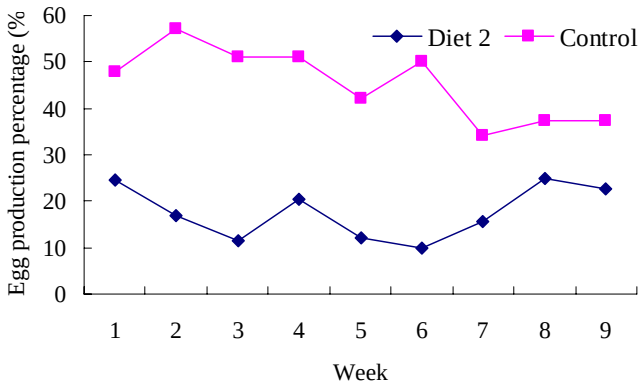

Figure 6. The egg production percentage (%) for birds fed diet 2 compared to birds fed the imported commercial layer diet (control).

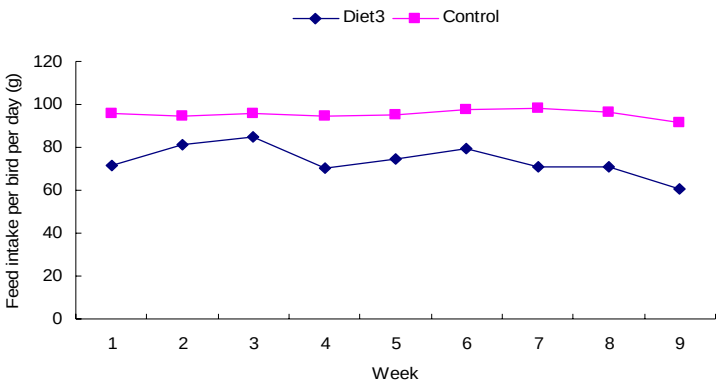

Figure 7. The feed intake (g/d/bird) for birds fed diet 3 compared to birds fed the imported commercial layer diet (control).

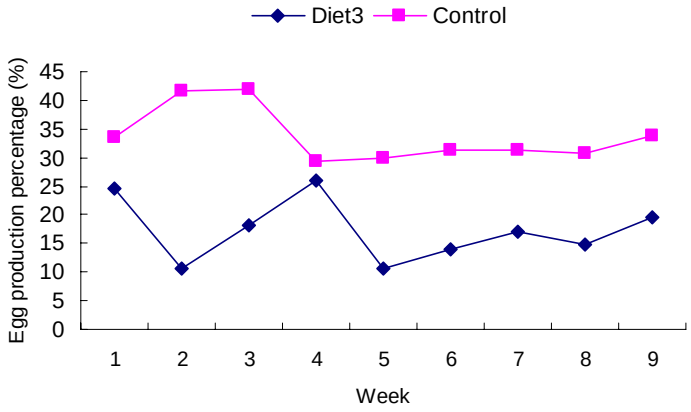

Figure 8. The egg percentage (%) for birds fed diet 3 compared to birds fed the imported commercial diet (control).

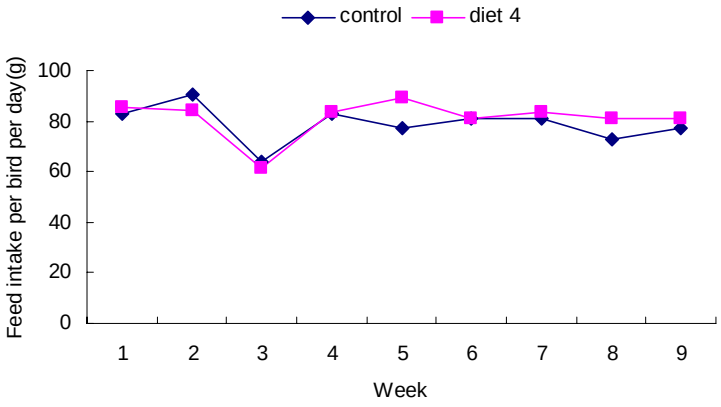

Figure 9. The feed intake (g/d/bird) for birds fed diet 4 compared to birds fed the imported commercial layer diet (control).

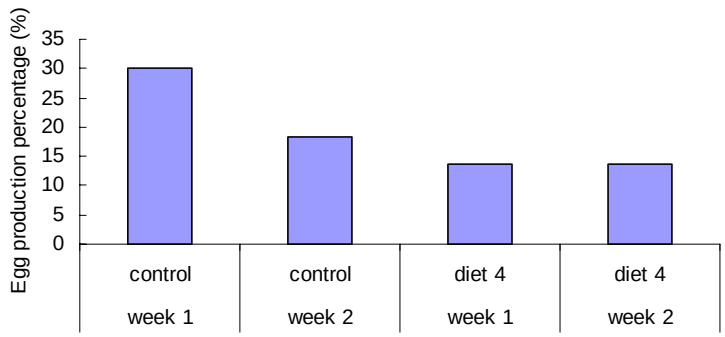

Figure 10. The egg percentage (%) for birds fed diet 4 compared to birds fed the imported commercial diet (control).

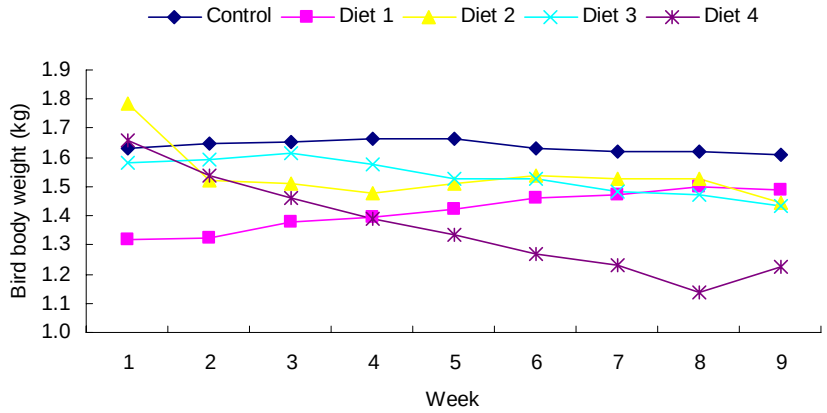

Figure 11. Overall bird body weight compared to average of control birds

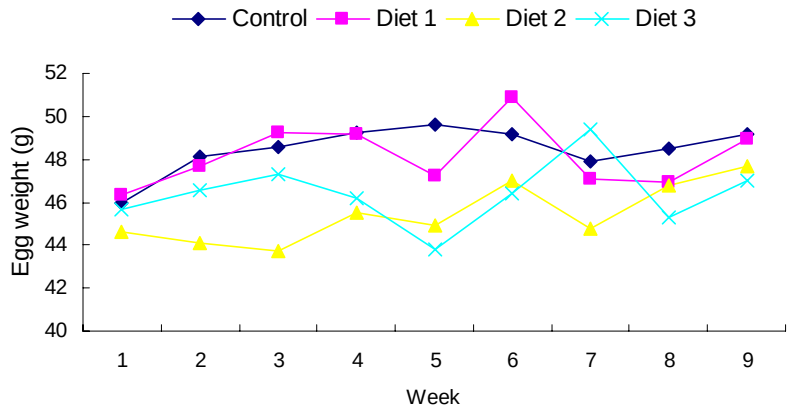

Figure 12. Overall egg weight compared to average of control birds

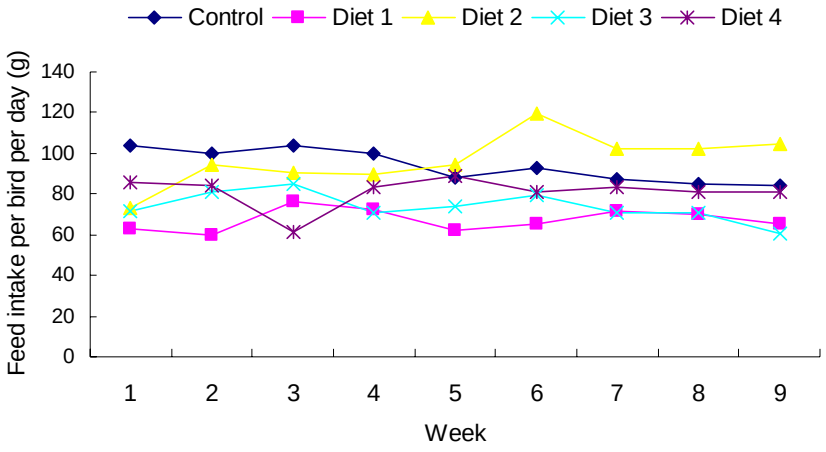

Figure 13. Overall feed intake per bird per day compared to average of control birds

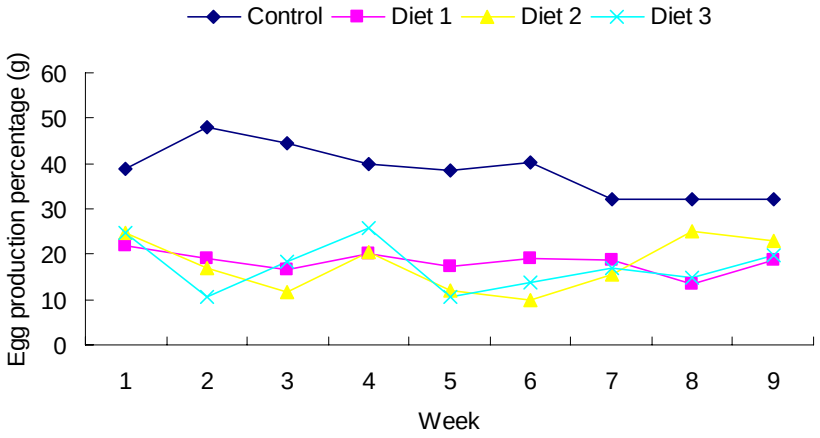

Figure 14. Overall egg production percentage compared to average of control birds

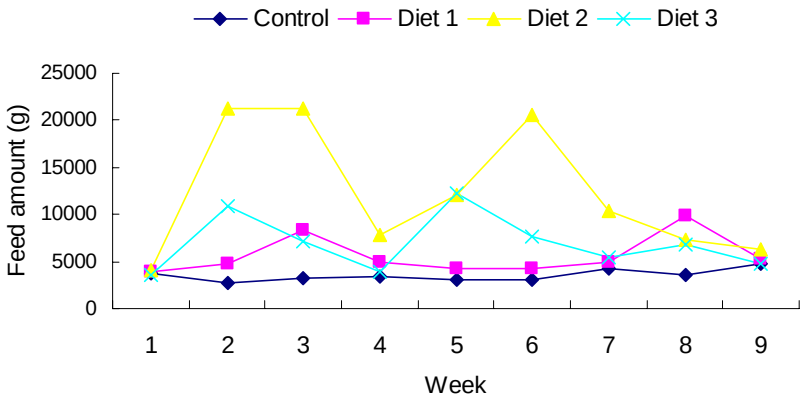

Figure 15. Overall feed amount needed to produce 12 eggs compared to average of control birds

7.3 Interact with farmers and farmer groups to evaluate, disseminate and communicate the value of rations based on local feedstuffs

7.3.1 Survey results

A total of 90 farmers in 31 villages of Guadalcanal, Western, Malaita and Central Provinces of the SI were surveyed to obtain baseline information on the current feeding practices and farmer attitudes to village poultry production. Village chicken farming in the SI is conducted on a small scale. Most surveyed farmers thought chickens were easy to care for, provide food for the family and was a good cash income enterprise (Figure 16). Some farmers were interested in keeping local chickens, but found it difficult to obtain the birds. The main feed sources are fresh coconut, copra meal, fish meal, mill run, food scraps and forage sources from the range (Figure 17). Many villagers lacked the knowledge of managing a village poultry enterprise. For example, some villagers believe that chickens only need to eat household scraps and did not need to be providing drinking water. There were also a lack of poultry housing resulting in losses of eggs and chickens. Some chicken houses were built by using bush materials or by purchasing construction materials. Potential farmers indicated they would like to keep chickens, but need the government to provide funds for establishing a small holder poultry enterprise and to provide information on feeding (Table 1) and management of birds (more detailed results listed in Appendix 3).

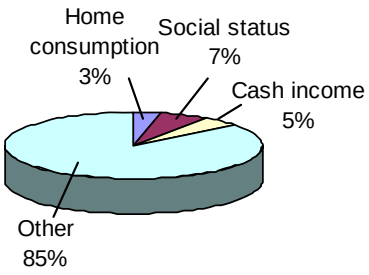

Figure 16. The reasons why farmers keep village chickens.

Note: Other includes combination of home consumption, cash income and social status.

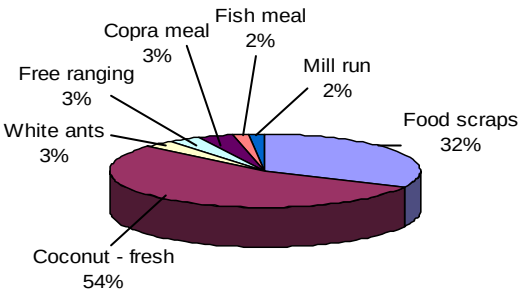

Figure 17. The main sources of feed ingredients in the Solomon Islands.

Table 1. The reasons why SI villagers were not keeping village chickens

Reason	Percentage (%)
No access to feed and birds	27
Do not know how	22
Finance and market	16
Predators	11
Stealing	8
Disease	3
Other (no house, no fence or no chickens)	14

7.4 Train provincial extension agents, NGO staff and farmer leaders in effective farmer communication strategies and poultry management

The extension had a focus on training and demonstrating models of improved management of local chickens including basic training and information on poultry feeding and management. Farmer attachments involving village farmers were organized by KGA at Burns creek poultry extension facility during the project. The farmers learnt how to feed, house and care for village poultry. The KGA attachment program generated good results with the majority of students putting into practice the feeding and management skills learnt. Farmers from Turusuala set up the improved feeding and management model on the remote weather coast of Guadalcanal. A number of villagers returned to the village, built a raised floor poultry house and fed the bird's pawpaw, coconut, sweet potato and cassava. Some farms also planted crops of cow peas, beans and sorghum to feed to the chickens. This activity generated interest from other farmers.

Demonstration feeding trials for village chickens were also established by KGA at Turusuala Training Centre and Gwaunafiu and Sausama Farmer Schools. A demonstration trial with village poultry was completed at the KGA comparing a free choice diet with a mixed diet. Workshops organised at farmer schools were run for 3 days with a mixture of theory and practical. In Malaita workshops were held after attachment trainees returned home as well as workshops in West Kwaio and West Kwara'ae in Malaita. In West Kwaio 19 people were trained, 10 women have started keeping improved local kokorako since they were trained. In West Kwara'ae 19 were trained and 6 men have set up models.

7.4.1 KGA Burns Creek Demonstration Centre

KGA established a much improved feeding, breeding and management system for carrying out training, trials and demonstrations. The KGA demonstration centre also provided seed stock for trials (sorghum, mung bean, cowpea, Japanese kabis, pigeon pea, long beans, clover) and chickens for farmers.

The demonstration trails for farmers conducted at Burns Creek included comparing mixed local feed with free choice. The mixed feed resulted in better production than free choice feeding. A second trial compared a commercial ration with a commercial ration diluted with a local feed. The results showed that the commercial diet can be diluted by 50% with a mixed local feed. Egg production was reduced by 18%, but the cost reduction was 50%. A third trial involved feeding maggots to village chickens. Birds fed maggots had higher egg production than a diet containing fish meal. Maggots could be used as an alternative protein source for local chickens. Simple methods of producing maggots for use in feed need to be further investigated.

KGA demonstrated village poultry models in Gwaunafiu, Turusuala, Sausama, Tanagai farm schools. In the attachments, young farmers were trained in farmer schools (6 in Western Province). These attachments were combined with an EU project. Other rural training centres were also involved in the Burns Creek attachments with less formal involvement in the project: eg. Vatu (Guadalcanal), Kuzi (Western Province) and Sepi (Malaita). Farmer workshops in Guadalcanal (2), in Malaita (3), Makira (2), Western Province (2) were conducted by KGA and MAL staff. Information on theory and practical management of poultry were delivered to village farmers. A total 178 of farmers attended workshops. Newsletters and manuals giving basic management advice were handed out to farmers.

7.4.2 Extension of research results

Farmer schools

Four farmer schools were selected to conduct farmer trials and demonstrate research results to farmers.

Farmer School Results

3 of 4 farmer schools are continuing with their models. The Tsunami destroyed one farmer school at Sausama but it is functioning again.

Gwaunafiu farmer school

A sustainable model was established with some practical improvements made. The farmer school is widely used by local farmers and there are plans to use it as a training centre for extension. One trial was undertaken but no results were recorded.

Turusuala farmer school

Turusuala model was closed due to continuing problems with dogs and theft but students have set up their own models as part of home projects and these models are now used to train others. Poultry farming methods are spreading in the communities.

Sausama farmer school

The poultry farming model continues to operate. The farmer school and associated farmer groups remain very strong and organised. A trial of free choice versus mixed feeding was conducted. No records were kept; only farmer observation. Free choice was observed to be better.

Tanagai farmer school

This centre no longer functions due to problems with management. However, for two years there was extensive training in the community and western Guadalcanal. Farmers heard about attachments through the PMN network. Some project sponsored attachments of six young farmers was done through attachments with farmer schools in Western Province. These attachments were combined with an EU project. Other rural training centres were also involved in Burns Creek attachments with less formal involvement in project: eg Vatu(Guadalcanal), Kuzi (Western province) and Sepi (Malaita). Trials done were very informal, but farmers could not be convinced to keep records despite receiving training in record keeping.

7.4.3 Results from follow up visits

The numbers of chickens being kept ranged from 10-40. Poultry were distributed by KGA and from the SICHE breeding facility to some successful farmers.

- 42 chickens distributed to five farmers (ranged from 2 to 11 chickens each).

- Transport and logistics proved difficult.
- Farmers have been sharing their knowledge with other farmers in the area
- Some students are in regular contact with KGA through letters and by radio

20 farmers who were trained in 2007 on attachment were visited in 2008 by KGA. 90% of those visited had established a new poultry house for chickens and management was based on what they had learnt on attachment.

7.4.4 Farmer workshops

Workshops were conducted by KGA and MAL staff over 3 days with a mixture of theory and practice.

Table 2. Number of farmers attending the workshops

Province	Male	Female	Total
Guadalcanal (2)	No data	No data	29
Makira (2)	11	21	32
Western Province (2)	48	21	69
Malaita (3)	33	15	48
Total			178

In Malaita workshops were held after attachment trainees returned home to their village.

7.4.5 Follow up to workshops

Two workshops in West Kwaio and West Kwara'ae in Malaita were followed up. In West Kwaio it was found that of 19 people trained, 10 women had started to keep village poultry since the training. The West Kwaio trainee was a woman. This was achieved with assistance from a farmer attachment trainee. In West Kwara'ae 19 were trained and 6 have set up models (all men).

7.5 Produce and distribute information in a variety of appropriate forms and manners to stakeholders in the poultry sector

7.5.1 Fact sheets

Draft one-page information leaflets on best practice feeding methods for village poultry were developed by SARDI. The leaflets show pictures of the feed ingredients, how they are prepared, amount of each ingredient to include in the diet based on a coconut measure and how the diet is fed to birds. Fact sheets are being distributed to farmers by MAL, SICHE and KGA.

7.5.2 Newsletters

One PMN Newsletter was printed and distributed to members with a focus on poultry and outputs from project. Handouts on poultry in the Newsletter provided basic management advice for interested farmers and was also given to students on attachment.

7.5.3 Radio

Some students maintain regular contact with KGA via letters and through the radio network. Training information was also provided to farmers over the radio network.

7.5.4 Handbook

The KGA poultry trainer's handbook and farmer's booklet developed by KGA included information generated from the project for distribution through the KGA village farmer network.

7.6 Evaluate the nutritional value and palatability of herbs

There is growing interest in using herbs as a substitute for synthetic antibiotics in poultry diets. Herbs have been used by humans as health foods to overcome various ailments and could be used for livestock. Two trials were conducted to determine the production of broilers grazing on fresh herbs. In the first trial, rosemary and thyme were used. The chemical composition and mineral content of rosemary and thyme were similar except for the high Mn and Fe content in thyme and high gross energy content in rosemary. There was no significant ($P>0.05$) difference in daily weight gain between treatments which ranged from 68.2-70.7g, but feed conversion rate (FCR) was better ($P>0.05$) for rosemary (2.0) and thyme (2.0) treatments compared to the control (2.3). Estimated herb intake was 15.9g/day/bird for rosemary and 16.0g/day/bird for thyme. Birds feeding on rosemary and thyme had a heavier wet crop content (48.4 and 67.1g respectively) and dry crop content (20.7 and 20.9 respectively) compared to the control (12.7 for wet and 4.3 dry crop content respectively) at 45 days of age. Dry weight of crop tissue was heavier ($P>0.05$) for birds feeding on thyme (4.2g) compared to rosemary (2.4g) and the control (2.3g). Meat flavour from rosemary (3.41) and the control (3.48) treatment was better ($P<0.05$) compared to thyme (3.41). Grazing on fresh herbs did not significantly influence bird growth in this trial, but improved the FCR although this was not significant.

In the second trial, fennel and sage were used. Results showed that there was no significant ($P>0.05$) difference in daily weight gain and FCR between treatments; Estimated herb intake was 8.6g/day/bird for fennel and 5.0g/day/bird for sage. Birds feeding on fennel and sage did not affect ($P>0.05$) wet crop or dry crop content compared to the control. However the moisture content of the crop and the weight of empty crop tissue were significantly ($P<0.05$) higher than that of the control. Sage leaf and stalk had higher gross energy and crude fibre content compared to that of fennel while Fennel leaf and stalk had higher Na and S content compared to sage. In summary, there was no impact of herb feeding on production but some changes in crop tissue weight were observed which requires further investigation. The health aspects such as the development of digestive track and the effect on bird gut bacteria profile is also worth investigation (paper listed in Appendix 4). Fresh herbs could be included in a free-range crop or pasture rotation for birds to graze.

7.7 Communication of herb information to the industry in Australia

7.7.1 SARDI website

At the completion of all the trials the SARDI website was upgraded with information on use of herbs in organic free-range systems

7.7.2 World Poultry Congress (WPC)

An oral presentation of the 'Performance of broiler growers grazing on fresh herbs; rosemary (Rosemarinus officinalis), thyme (Thymus vulgaris), fennel (Foeniculum vulgare) and sage (Salvia officinalis)' was delivered by Dr Miao at the 23rd WPC,

Brisbane in July 2008. The abstract of this paper was published in the World's Poultry Science Journal, Vol 64, Supp 2. p. 363.

7.7.3 Feed info

A paper on 'Performance of broiler growers grazing on fresh herbs; rosemary (Rosemarinus officinalis), thyme (Thymus vulgaris), fennel (Foeniculum vulgare) and sage (Salvia officinalis)' was published on 'FeedInfo', which is a news and scientific information provider for the global food and livestock industries.

7.7.4 Publications

Miao, Z.H., Glatz P.C., Rodda, B.K. and Wyatt, S.C. (2008). Performance of broiler growers grazing on fresh herbs; rosemary (Rosemarinus officinalis), thyme (Thymus vulgaris), fennel (Foeniculum vulgare) and sage (Salvia officinalis). (Abstract). XXIII World's Poultry Congress 30 June-4 July 2008. World's Poultry Science Journal, Vol 64, Supp 2. p.363

Miao, Z.H., Glatz, P.C., Rodda, B. K. and Wyatt, S.J. (2008). Performance of Meat Birds Grazing on Fresh Herbs; Rosemary (Rosemarinus officinalis), Thyme (Thymus vulgaris), Fennel (Foeniculum vulgare) and Sage (Salvia officinalis). Feedinfo News Service Scientific Reviews. August 2008. Available from URL: http://www.feedinfo.com."

Jansen, T., Glatz, P.C. and Miao, Z. H. (2009). Village poultry production in the Solomon Islands. Tropical Animal Health and Production (in press).

8 Impacts

8.1 Scientific impacts – now and in 5 years

There are considerable benefits flowing from this project for the village and commercial sectors in the SI. The results from trials suggest that local feeds could be fed to imported layers especially as import costs of feed continue to rise. However there will be a drop in egg and meat production but it is likely to be out weighed by the reduced feeding costs. Other rations to feed birds are being developed by the project partners including the use of locally produced oils in feeds which have been reported to have an antimicrobial function. This may result in a significant benefit to village bird's health and improve the feed conversion ratio.

8.2 Capacity impacts – now and in 5 years

The development of personnel capacity in this project is likely to sustain R&D activities in the SI over the next 5 years if funding support is provided by the SI government. The persons trained in the project included;

Joseph Wahananiu (MAL scientist) and Hilda Karani (KGA-technician) who undertook training at the PPPI from 29 July-13 August 2005 in the feed evaluation unit. The training included working with PPPI staff carrying out daily husbandry activities associated with a feed trial, assisting with bird dissections, preparing samples for storage and visiting commercial farms where an on-farm research trial was being conducted. These two staff have been key personnel in the project. Joseph was instrumental in completing the feeding trials and training SICHE students in production research protocols and Hilda in training farmers and students who participated in the attachment program at KGA

Barney Kequa was awarded a JAF and commenced a course work master's degree in February 2008. His project focuses on identifying phylogenetic characteristics of village poultry in the Solomon Islands. This work is likely to lead to greater recognition of the importance of village chickens in village farming systems throughout the Pacific.

KGA conducted farmer workshops on improved poultry feeding and management with over 100 village participants in Malaita and Western Province. KGA has hosted 30 farmer attachment programs (1-6 months duration) at the Burns Creek poultry extension facility during the project. The KGA attachment program is generating good results with the majority of participants putting into practice the poultry feeding and management skills learnt.

More farmers would like to use the trial results and more farmers have been trained and are sharing information with others. This will encourage more farmers to keep local chickens for income or consumption in the SI. Poultry production will be improved by using diets formulated using local available feed ingredients. The production of local chickens and profit will increase over time for poultry farmers in SI. In the mean time, more eggs and more chickens are expected to be consumed by families to improve the nutritional status of village families. The basic knowledge of feeding and managing local chickens is expected to be shared with the community in the rural areas.

8.3 Community impacts – now and in 5 years

The survey of village poultry farms conducted early in the project identified that SI favour consumption of village hen meat and eggs due to flavour and texture of the meat. This preference is in contrast with the majority of European and Australian consumers. Currently there is a shortage of village hens in the SI but by using appropriate rations made from locally available feeds there is potential to increase egg production and the number of birds kept by 25%. Increased production by village farmers could reduce price of eggs and chicken meat. That would be beneficial for consumers, and justify our efforts to improve efficiency of production and profitability of village poultry farms. If rural area farmers could use trial results from this project to produce more eggs and chicken meat, the situation of an average 30% of infants underweight due to poor nutrition would be improved. This is because regular addition of eggs and chicken meat combined with more green vegetables in family diets has the potential to reduce infant malnutrition that has a much wider cost to society. KGA experiences have shown that a production unit of 20-40 village chickens can provide eggs for the family and sale every day and a regular supply of meat birds for consumption or sale.

The poultry research facilities, demonstration trials and better rations formulated by available local feed ingredients, extension work, training and attachments for poultry farmers has improved the knowledge of poultry farmers on poultry feeding and management. The better feeding strategies developed from this project will improve the local chicken production system and is being adopted by farmers. A number of the commercial and semi-commercial poultry enterprises in the SI have closed down due to the huge increase in cost of imported feeds. This may open new market opportunities for village-based production systems, particularly in areas where access to urban markets is possible.

8.3.1 Economic impacts

It is clear that where poultry production has been promoted there has been an increase in the number of birds kept by 25%. Expansion of this initiative into other South Pacific Islands could realize substantial economic benefits to the region. There is considerable volatility in the poultry sector, as the commercial and semi-commercial components are under pressure from the rising cost of imported feeds. This may open new market opportunities for village-based production systems, particularly in areas where access to urban markets is possible.

8.3.2 Social impacts

This project has had two important social benefits; one is to increase income for the rural farmers and another is to improve family nutrition. The production of eggs and chicken meat is one of the few cash generating activities for many rural farmers. Second, eggs and poultry meat are among the few sources of high quality protein for many people in Solomon Islands. The survey of village farmers indicated that villagers thought chickens were easy to care for and a good enterprise for providing cash income and extra food for the family. Other farmers were interested in farming but there was a shortage of village chickens. KGA have been conducting training of village farmers through on-farm training and their attachment program. In inland areas of the Solomon's, eggs and poultry meat are among the few sources of high quality protein for many people. Malnutrition remains a major problem in the SI, and eggs and vegetables have been identified as the most likely means of redressing this problem.

8.3.3 Environmental impacts

There are no anticipated changes to the environmental status of smallholder village chicken production in the Solomon Islands. Village farmers who have established poultry sheds use the poultry manure for use as fertilizer in their gardens. The use of local feed sources in rations will not impact on the environment although more land may be utilised for growing of local crops.

8.4 Communication and dissemination activities

Information and knowledge were delivered to the farmers by extension workers. This was done by KGA through farmer schools at Gwaunafiu, Turusuala, Sausama and Tanagai. Young farmers were trained through attachments with farmer schools. Other rural training centres were also involved in Burns Creek attachments. Workshops were conducted to deliver a mixture of theory and practical information. Others such as one-page information leaflets on best practice feeding methods for village poultry were circulated at these meetings. The leaflets show pictures of the feed ingredients, how they are prepared, amount of each ingredient to include in the diet based on a coconut measure and how the diet is fed to birds. The KGA poultry trainer's handbook and farmer booklet including information generated from the project were distributed through the KGA village farmer network. At the completion of all the trials, the results were published on the SARDI website and Roseworthy Information Centre. Abstract of herb feeding was published in the World's Poultry Science Journal and the paper was published on "FeedInfo".

9 Conclusions and recommendations

9.1 Conclusions

Using local available feed ingredients to feed local chickens is effective in reducing the cost of feeding village chickens. There is a wide variety of local feed resources available that could be utilized more effectively such as root crops, fruit, forages, bush plants and vines. Farmers in the rural areas are introducing new crops with higher nutritional value for poultry such as sorghum, mung bean and pigeon pea. This project has established the infrastructure and capability in the SI to test and identify effective rations for village birds based on the wide variety of potential feeds and has developed the skills of staff to educate farmers on poultry feeding management. This information was delivered to the farmers by extension workers who provided training, demonstration and visits to farmers. Trained farmers were able to share information with other farmers which has enabled more farmers to keep chickens efficiently and produce more eggs and chicken meat for family consumption and local market. The results generated from this project will help farmers to feed and manage village chickens, and prepare rations for chickens based on their own available feed ingredients and hence reduce the cost and increase the profitability for local chicken farmers. The facilities established from this project were important for research and teaching and has been used as a model for other research sectors to collaborate with MAL, SICHE and KGA.

9.2 Recommendations

At the final review meeting of the ACIAR project on 21/10/2008 partners from MAL, SICHE, KGA and SARDI a number of suggestions were made regarding a project extension or development of a new project. This project would follow on from the success with the ACIAR project “Feeding Village poultry in the Solomon Islands”. The project established a unique collaboration between the partners, built a poultry feed research and breeding facility at SICHE operated by the MAL, KGA and SICHE. Staff were trained to run the facility and feeding trials recommended various diets for village poultry based on local feed resources that have been adopted by village farmers involved in the extension program.

All the partners are now keen to continue on with their project success and run a project to develop a feed manufacturing industry in the Solomon’s with support from ACIAR and from other partners such as Regional Assistance and Management SI (RAMSI), AusAid, European Union (EU) micro projects office and commercial partners. In addition the project team wish to support SICHE in their mission to become the first University in the SI by establishing additional livestock and feed manufacturing facilities in keeping with the standards required of a tertiary institution.

The proposed project will develop a local feed industry and reduce the huge costs to the SI of importing livestock feed (particularly pig and poultry feed) and the associated high costs of eggs, chicken meat and pork in urban areas. In remote locations of the Solomon Islands the establishment of small scale feed mills and provision of cheaper feed will encourage village farmers to expand their livestock operations and for other farmers to enter into the market.

Personnel involved in the smallholder and the semi commercial feed industry must develop the expertise to manufacture the diets. The majority of smallholder farmers lack basic nutritional knowledge necessary to formulate practical, nutritionally adequate diets from locally available ingredients. Many also lack the necessary skills

and experience to make high quality farm-made feeds suitable for feeding pigs and poultry. Knowledge on the infra-structure required to produce and store dried feeds and ingredients is also limited.

Proposal: Development of a livestock feed industry in the Solomon Islands

- 8 semi commercial livestock feed milling plants are proposed to be purchased by MAL for the Solomon's through an Food and Agriculture Organisation (FAO) expansion phase project in 2009. This may include hand operated equipment suitable for individual village farmers.
- For the feed milling operation to be successful it is important a user brief is written to detail the establishment of small scale and medium scale milling equipment. This would include details on type of equipment (choppers, dryers, hammer mills, mixers, pelleters etc), location of plant, power requirements, sheds to house equipment, flooring, tools, storage bins for ingredients and prepared feeds, weighing equipment etc.
- Poultry keeping is differentiated into three phases in the SI based on care given (no care, low care, and high care). The no care group is defined as remote villages with up to 50 birds which could use small scale, hand driven milling equipment. The low care group is defined as remote village large scale systems with up to 250 birds which are also serviced with hand driven milling equipment. The high care group comprises individuals or cooperatives with up to 2,000 birds total; or individuals or cooperatives with over 5,000 birds total) which could utilise semi-commercial small scale feed milling equipment (up to 2 tonne per week) with a mechanised power source, and semi-commercial large scale (5-10 tonnes per week) with mechanised power source
- Our project team have recommended to MAL that small and medium scale plants be established firstly at SICHE using funds (if approved) through an EU community project run in association with the poultry research and breeding centre. At SICHE staff will be trained to run the plants for MAL (in their FAO expansion phase project) and also to train village farmers in use of micro mills or hand operated equipment. These staff would receive training in all aspects associated with feed preparation.
- It is suggested that ACIAR provide funds to support training and R&D activities to further develop suitable rations based on use of by products from commercial partners Koconut Pacific SI (KPSI) and Asian Vegetable Research and Development Centre (AVRDC)
- RAMSI have suggested that we integrate the feed extension program with the AusAid Rural Development Program to promote feed manufacturing.
- Ravi Joshi from the AVRDC is keen to examine the potential of processing some of the vegetable by products for use as ingredients in livestock rations. Soil fertility in the Solomon's is poor and pig and poultry manure is essential to improve the fertility of the soil and improve yields of vegetables. This makes it important for vegetable production to be integrated with poultry farming particularly at the village level.

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Wilkinson, L., 1996. Systat 6.0 for Windows-Statistics. S P S S Inc., USA.

10.2 List of publications produced by project

Z.H. Miao, P.C. Glatz, B.K. Rodda and S.J. Wyatt. 2008. Performance of broiler growers grazing on fresh herbs; rosemary (Rosemarinus officinalis), thyme (Thymus vulgaris), fennel (Foeniculum vulgare) and sage (Salvia officinalis). In: Proceedings of XXIII Would's Poultry Congress 2008. World's Poultry Science Association. Brisbane, Australia. Book of Abstracts, supplement of the World's Poultry Science Journal, Vol 64, supplement 2. p.363.

Z.H.Miao, P.C.Glatz, B.K. Rodda and S.J.Wyatt 2008. Performance of Meat Birds Grazing on Fresh Herbs; Rosemary (Rosemarinus officinalis), Thyme (Thymus vulgaris), Fennel (Foeniculum vulgare) and Sage (Salvia officinalis). Feedinfo News Service Scientific Reviews. August 2008. Available from URL: http://www.feedinfo.com."

T. Jansen, P.C. Glatz and Z. H. Miao 2009. Village poultry production in Solomon Islands. Tropical Animal Health and Production (in press).

11 Appendices

11.1 Appendix 1: Feed ingredient fact sheets for the Solomon Islands

11.1.1 Feed Ingredient Fact Sheets

Introduction

This feed ingredient description sheet provides a general guideline for the use of feed ingredients for poultry in Solomon Islands. 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 fact sheet contains the name, general description, chemical composition, nutritive value and anti-nutritional factors for each ingredient. It also provides guidelines on the use of these ingredients in pig and poultry diets.

Common name: Fishmeal

Description: Fishmeal is produced from fish/fish trimmings which are cooked/separated from the oil, dried presses, ground and treated to form a meal. Whole fish from carefully managed stocks of species deemed unsuitable for human consumption are the main constituent of fishmeals. Fishmeal quality depends on the manufacturing process. Generally, the more gentle during the process, the higher the quality of the meal (Ewing, 1997). Fishmeals provide high contents of protein, amino and fatty acids (particular essential amino and fatty acids). Fishmeals are low in carbohydrates and usually well digested (Allan et al., 2000). Fishmeal is high in lysine which represents 7-8% of the total nitrogen, and has good content of sulphurated AA and tryptophan. The amino acids are better used that those of meat meals. Fishmeal is an excellent source of protein for poultry due to adequate quantities of all indispensable amino acids and particular rich in lysine and methionine (Scott et al., 1982). However, its use is generally limited in order to prevent a fishy taint to meat and eggs (Say, 2002).

Proximate composition

The chemical composition of fishmeal

	DM	CP	EE	Ash	CF	GE (MJ/kg)	Source
Aust. Fish meal (% dry basis)		73.2	9.9	14.2		21.3	Allan et al., 2000
Danish fish meal (% dry basis)		72.9	11.4	13.0		21.5	
Peruvian fish meal (% dry basis)		70.2	11.3	17.6		20.9	
Tuna fish meal (Cannery waste) (% fresh)	86.8	56.9	7.7	21.7	0.6		Anon. 2005

Minerals: Ca and P content of tuna fish meal (cannery waste) were 6.9% and 3.8% on fresh matter basis (Anon. 2005).

The mineral content of fishmeals (%) (Ewing, 1997)

	Chilean	Herring	Whiter	Scottish
Salt	2.5	2.2	2.5	2.5
Ca	3.5	2.7	6.8	3.0
Total P	2.7	2.7	3.5	3.5
Avail. P	2.3	2.1	3.3	3.0
Mg	0.3	0.2	0.3	0.3
K	1.3	1.3	1.0	1.1
Na	1.0	0.8	1.1	1.1
Cl	1.5	1.5	1.5	1.6

Amino acids: the amino acid content of fishmeals

	Aust. Fish meal1 (%DM)	Danish fish meal1 (%DM)	Peruvian fish meal1 (%DM)	Fish meal2 (%)	Fish meal3 (China %DM)	Fish meal3 (Peruvian %DM)
Lys	6.9	6.2	5.5	4.1	3.3	5.2
Met	2.3	2.2	2.0	1.8	1.3	1.4
Cys	1.0	0.8	0.7			
Thr	3.9	3.6	3.2	2.8	1.7	2.9
Arg	6.0	5.9	5.1	4.5	3.0	4.3
Gly	5.1	5.1	4.8		3.6	4.8
Ser	3.6	3.6	3.0	3.5	1.3	2.4
His	2.7	1.9	2.3	1.4	1.2	1.9
Ile	3.6	3.4	3.5	2.4	2.5	2.9
Leu	5.9	5.6	5.3	4.7	3.6	4.9
Phe	3.3	3.0	2.9	2.6	2.8	2.9
Tyr	2.7	2.3	2.3	2.0		1.5
Val	4.0	3.8	3.7	3.0	2.3	4.1
Pro	3.4	3.2	3.5		0.7	0.8
Ala	5.0	4.8	4.6	4.0	3.3	4.3
Glu	10.2	10.2	9.4	8.6	7.4	10.0
Asp	7.6	6.7	6.2	5.7	4.6	7.0

1 Allan et al., 2000; 2 Ravindran et al., 1998; 3 Yin et al., 1993;

Anti-nutritional factor: High level of ash. High-level inclusion in poultry diets may cause gizzard crown and egg taint (Ewing, 1997).

AME and digestibility: AME and TME of fishmeal was 13.14 and 14.85 MJ/kg. Energy digestibility of fishmeal was 48.8% (Gous and Dennison, 1983). ME content of tuna fish meal (cannery waste) was 11.4 MJ/kg on fresh matter basis (Anon. 2005).

The amino acid digestibility of fishmeals

	Fish meal_ID (%)1	Fish meal_ED (%)1
Aspartic acid	70	79
Glutamic acid	82	82
Serine	70	79
Histidine	76	80
Threonine	74	81
Arginine	84	86
Alanine	81	77

Tyrosine	82	80
Methionine	87	87
Valine	83	80
Phenylalanine	83	83
Isoleucine	86	82
Leucine	85	85
Lysine	86	85

1 Ravindran et al., 1998; ID=ideal digestibility; ED=excreta digestibility;

DE and digestibility: Ideal digestible energy of fishmeal (China) for pigs was 14.05 MJ/kg DM, DE and ideal digestible energy of fishmeal (Peruvian) were 18.59 and 18.39 MJ/kg DM, respectively (Yin et al., 1993). DE content of tuna fish meal (cannery waste) was 12.2 MJ/kg on fresh matter basis (Anon. 2005).

Amino acid ideal digestibility of fishmeals (Yin et al., 1993)

	Fishmeal (China) (%)	**Fishmeal (Peruvian) (%)**
Aspartic acid	61	90
Glutamic acid	71	90
Serine	57	90
Histidine	85	87
Glycine	52	75
Threonine	82	89
Arginine	71	87
Alanine	63	90
Tyrosine	68	87
Methionine	69	88
Valine	61	89
Phenylalanine	61	86
Isoleucine	63	88
Leucine	84	89
Lysine	67	88
Pro	68	87

Inclusion in diets:

- Pigs: Recommended inclusion for weaners 10%, growers 7.5%, finisher 4% and sow 3% (Ewing, 1997).
- Poultry: Recommended inclusion for chicks 5%, broilers 5%, breeders 5% and layer 2.5% (Ewing, 1997).

Common name: Cowpea

Scientific name: Vigna unguiculata

Description: The protein content of cowpea about 20% with low in methionine and high lysine content (Petterson and Mackintosh, 1994). Although there is no evidence of toxicity when cowpea seed included in pig and poultry diets, the weight gain usually decreases as the percentage of raw beans increases in the pig and poultry ration. This effect can largely be eliminated by autoclaving the beans (at 121°C for 15 min.) before feeding (Gohl, 1981). Cowpea hay is an excellent roughage for all kinds of livestock; if chopped and moistened, it is suitable for poultry as well. Yields of fresh fodder can be increased by cutting the plants twice in a season (Gohl, 1981).

Proximate composition:

The chemical composition of raw and autoclaved (at 2.109 kg/cm2 for 30 min. dried at 85ºC for 24 h) white and brown varieties of cowpea

	DM	CP	EE	Ash	CF	NFE	Starch	GE(MJ/kg)
White, raw1 (% as fed)	81.2	21.3	1.5	3.5	5.3	49.6		16.5
Brown, raw1 (% as fed)	80.7	21.6	1.4	3.7	5.9	48.0		16.8
White autoclaved1 (% as fed)	78.9	20.9	1.4	3.3	5.2	48.1		16.7
Brown autoclaved1 (% as fed)	79.1	21.0	1.4	3.2	5.8	47.7		16.7
Meal with high CP content2 (%DM)	90.6	30.2	1.3	3.8	5.0		40.1	
Meal with low CP content2 (%DM)	90.4	27.4	1.1	3.5	5.6		41.7	
Raw meal2 (%DM)	91.1	28.4	1.2	3.4	5.2		41.3	
Autoclaved meal2 (%DM)	90.1	28.9	1.4	3.3	5.3		40.6	
Cowpea (cv. Red Caloona)3 (%)	89.6	22.4	1.2	3.6	6.0			17.2
Cowpea (cv. Caloona) 3 (%)	88.6	23.0	1.2	3.4	5.6			17.0
Cowpea4 (% dry basis)		25.2	2.3	3.7				18.8

1Nwokolo and Oji, 1985; 2Nell et al., 1992; 3 Robinson and Singh, 2001; 4 Allan et al., 2000;

Minerals: Lestuenne et al. (2005) reported that Fe and Zn content of cowpeas 6.60 and 3.78 mg/100g DM.

The mineral content of cowpeas

	Ca	P
Meal with high CP content1 (%DM)	0.13	0.49
Meal with low CP content1 (%DM)	0.1	0.52
Raw meal1 (%DM)	0.13	0.5
Autoclaved meal1 (%DM)	0.12	0.51
Seeds2 (%)	0.72	0.47

1Nell et al., 1992; 2 Petterson and Mackintosh, 1994;

Amino acids: the amino acid content of cowpeas

	Cowpeas1 (% DM)	Meal2 high CP content (% CP)	Meal2 low CP content (% CP)	Raw meal2 (% CP)	Autoclaved meal2 (% CP)	Cowpea3 (cv. Red Caloona) (%)	Cowpea3 (cv. Caloona) (%)
Lys	1.8	5.0	5.2	5.2	4.9	1.4	1.4
Met	0.4	1.2	1.1	1.2	1.1	0.3	0.4
Cys	0.3	1.1	1.1	1.1	1.1	0.2	0.2
Thr	1.0					0.8	0.8
Arg	2.2	5.1	4.8	5.0	4.6	1.5	1.5
Gly	1.1	3.0	3.1	3.1	3.1	0.9	0.9
Ser	1.4	4.2	4.3	4.4	4.3	1.1	1.1
His	0.8	2.4	2.3	2.4	2.3	0.6	0.7
Ile	1.2	2.8	2.8	2.8	2.7	0.8	0.8
Leu	2.0	5.7	5.1	5.8	5.8	1.6	1.6
Phe	1.4	4.2	4.2	4.4	4.1	1.2	1.2
Tyr	0.9					0.6	0.7
Val	1.3	3.3	3.4	3.4	3.4	1.0	1.0
Pro	1.3	4.6	4.9	4.8	4.9	0.9	0.9
Ala	1.1	3.3	3.4	3.4	3.4	0.9	0.9

Glu	4.7	14.3	14.2	14.1	14.1	3.3	3.4
Asp	3.0	9.5	9.5	9.4	9.6	2.1	2.1

1 Allan et al., 2000; 2 Nell et al., 1992; 3- Robinson and Singh, 2001.

Anti-nutritional factor: Trypsin inhibitors, lectins and tannins. Robinson and Singh (2001) reported that the trypsin inhibitor activity (mg/g) was 3.1 and condensed tannins was 0.8%. Petterson and Mackintosh (1994) reported that the total tannin content was 0.14%.

AME and digestibility: AME of cowpeas (white, raw; brown, raw; white autoclaved and brown autoclaved) was 11.4, 11.4, 12.4 and 12.7 MJ/kg respectively (Nwokolo and Oji, 1985). TME of cowpea meal and autoclaved cowpea meal for poultry was 12.34 and 12.98 MJ/kg as fed basis respectively (Nell et al., 1992). AME (MJ/kg) of cowpea (cv. Caloona and Red Caloona) was 8.4 and 9.4 respectively (Robinson and Singh, 2001). ME of cowpea was 12.2 MJ/kg DM (Gohl, 1981).

The amino acid availability of cowpeas for poultry

	Raw meal1 (%)	**Autoclaved meal1 (%)**
Val	73	76
Tre	77	80
Ser	79	83
Pro	85	86
Phe	75	74
Met	81	85
Lys	78	78
Leu	77	81
Ile	74	77
His	78	78
Gly	68	66
Glu	83	85
Cys	65	67
Asp	79	82
Arg	83	86
Ala	72	73

1Nell et al., 1992

DE and digestibility: DE of cowpea meal and autoclaved cowpea meal for pigs was 13.5 and 14.18 MJ/kg as fed basis respectively (Nell et al., 1992). DE for cowpea seeds was 14.0 MJ/kg (Petterson and Mackintosh, 1994).

Inclusion in diets:

Poultry: Robinson and Singh (2001) reported that 10-30% inclusions in layer diets were suitable.

Common name: Sunflower meal

Scientific name: Helianthus annuus

Description: Sunflower seed also has high oil content (450 to 500 g/kg in Spanish cultivars) and acceptable CP concentration (150 to 230 g/kg) (San Juan and Villamide, 2000). Consequently, whole sunflower seed may provide a convenient way to additional energy to broiler diets (Rodriguez et al., 1998). Hulled full fat sunflower seeds have a high energy content and relatively low price compared with other conventional nutrient sources (Ortiz et al., 1998). Oil extraction from sunflower seed

usually involves 2 consecutive procedures. First a mechanical treatment is applied. Most of the sunflower oil is released in this step. The by-product obtained can be called press extracted sunflower seed (PESFS). In the 2nd extraction, PESFS is subjected to the action of solvents, usually hexane with the rest of the oil being extracted. The final by-product is defatted sunflower seed meal (SFSM), which can be used in poultry diets as a protein source. The CP content of SFSMS depends on dehulling and oil extraction process, ranging from 29-45% (Spanish cultivars, FEDNA, 1994), in inverse relation to fiber content (from 32 to 14%). High fibre content and its deficiency of lysine are responsible for the limited use of SFSM in poultry diets (Villamide and San Juan, 1998; San Juan and Villamide 2000). Sunflower oil is a useful fat source for poultry, especially for laying hens, because of its high linoleic acid content.

Proximate composition: The chemical composition of hulled full-fat sunflower products

	Hulled full-fat sunflower seed (%DM)1	Sunflower seed (%DM)2	PESFS (%DM)2	Sunflower meal (%DM)2	Hulled full-fat sunflower seed3 (% as fed)
DM					96.7
CP	22.6	17.8	27.0	33.1	21.2
Crude fat	46.6	46.6	20.2	2.8	45.7
CF	14.3	14.5	21.0	25.2	13.4
Ash	2.6	3.8	5.7	7.0	2.6
NDF		23.6	34.2	38.9	21.7
ADF		16.5	23.7	29.5	17.5
ADL		5.0	7.4	8.5	
GE (MJ/kg)		26.3	22.2	19.4	

1Ortiz et al., 1998; 2 San Juan and Villamide, 2000; 3 Rodriguez et al., 1998;

Minerals: The mineral content of sunflower meals (%) (Ewing, 1997)

	Sunflower meal (Standard)	Sunflower meal (High protein)
Salt	0.25	0.25
Ca	0.3	0.35
Total P	1.2	1.3
Avail. P	0.35	0.4
Mg	0.6	0.65
K	1.2	1.2
Na	0.05	0.05
Cl	3.3	3.0

Amino acids: The amino acid content of sunflower meals

	Hulled full-fat sunflower seed (%DM)[1]	Sunflower meal (% as fed)[2]	Hulled full-fat sunflower seed (g/16 g N)[3]	Sunflower meal4 (32% CP) (% DM)	Sunflower meal4 (35% CP) (% DM)	Sunflower meal4 (37% CP) (% DM)
Aspartic acid	1.99	3.16	8.9	2.9	3.3	3.4
Glutamic acid	4.84	6.68	21.7	6.0	6.6	7.1
Serine	0.98	1.57	4.4	1.3	1.6	1.6
Histidine	0.65	0.81	2.9	0.7	0.8	0.9
Glycine	1.67		7.5	1.9	2.1	2.2
Threonine	0.69	1.32	3.1	1.2	1.4	1.5

Arginine	2.19	2.9	9.8	2.4	2.9	3.1
Alanine	1.09	1.46	4.9	1.4	1.5	1.6
Tyrosine	0.89	0.92	4.0	0.7	0.9	0.9
Methionine	0.4	0.85	1.8	0.7	0.8	0.8
Valine	1.07	1.6	4.8	1.5	1.7	1.8
Phenylalanine	1.03	1.55	4.6	1.4	1.6	1.7
Isoleucine	0.96	1.27	4.3	1.2	1.4	1.4
Leucine	1.43	2.2	6.4	2.1	2.4	2.4
Lysine	0.83	1.19	3.7	1.0	1.2	1.3
Cystine	0.49			0.5	0.6	0.6
Proline				1.2	1.4	1.5

1Ortiz et al., 1998; 2Ravindran et al., 1998; 3Rodriguez et al., 1998; 4Villamide and San Juan, 1998;

Anti-nutritional factor: Slightly laxative at high levels (Ewing, 1997).

AME and digestibility: AME of hulled full-fat sunflower seed was 17.05 MJ/kg DM (Cheva-Isarakul and Tangtaweewipat, 1991) and apparent crude fat digestibility was 84.2% (Rodriguez et al., 1998). Extrapolation of AMEn (MJ/kg MD) was 16.20 for sunflower seed, 9.46 for PESFS and 7.62 for sunflower seed meal for layers (San Juan and Villamide, 2000). AMEn of un-decorticated sunflower seed meal for cockerels was 6.1 MJ/kg DM (Mandal et al., 2005). AME and TME of sunflower oilcake was 8.48 and 10.27 MJ/kg (Gous and Dennison, 1983).

The TMEn content of different sunflower meals (Villamide and San Juan, 1998)

Sunflower meal	N	TMEn (MJ/kg DM)
A	9	6.5
B	9	6.5
C	6	8.1
D	8	7.8
E	8	7.9
F	8	8.0
G	8	7.8
H	8	8.0
I	8	7.7
J	6	7.9
K	8	8.4

The digestibility of amino acids of sunflower meals

	Sunflower meal_ID (%)[1]	Sunflower meal_ED (%)[1]	Sunflower meal2_AID	Sunflower meal2_TID
Aspartic acid	85	84	80.3	83.6
Glutamic acid	93	90	89	83.7
Serine	76	81	65.7	83.6
Histidine			81.3	83.7
Glycine			58.3	83.6
Threonine	76	77	62.3	83.6
Arginine	94	92	89.7	83.8
Alanine	87	78	79.7	83.6
Tyrosine	87	79	76.7	83.7
Methionine	95	93	87	83.9

Valine	87	80	79	83.6
Phenylalanine	90	86	84.3	84
Isoleucine	89	82	82.7	84.5
Leucine	88	83	81.3	83.7
Lysine	82	78	78.3	83.7
Cystine				

1 Ravindran et al., 1998; ID=ideal digestibility; ED=excreta digestibility; 2 Angkanaporn et al., 1996; AID=Apparent ideal digestibility; TID= True ideal digestibility;

DE and digestibility: The digestibility (%) and ME (MJ/kg DM) of sunflower cakes (Lekule et al., 1990)

	Sunflower cake [1]	**Sunflower cake [2]**	**Sunflower cake [3]**	**Sunflower cake [4]**
DM	63	58	48	54
OM	66	59	50	55
CP	78	81	70	75
Crude fat	63	62	70	87
CF	28	17	21	13
NFE	72	65	55	66
Energy	64	60	49	56
ME	12.17	11.17	9.00	10.45

Inclusion in diets:

- Pigs: Inclusion levels for grower 2.5%, finisher 5% and sow 10% (Ewing, 1997).
- Poultry: Lee and Yang (1980) reported that no significant difference in the performance of broilers fed on 0-50g/kg full-fat sunflower seed from 1 to 49 days of age. Daghir et al. (1980) reported that full-fat sunflower seed can be constituted at least 100g/kg of practical broiler diets without any adverse effect on performance. Rodriguez et al. (1998) reported that hulled full-fat sunflower seed can be used in broiler diets up to 250g/kg without adversely affecting either weight gain or feed efficiency. Zatari and Sell (1990) suggested that successful results in broiler chickens and laying hens using high levels of SFSM (20%) in diets formulated with adequate levels of lysine and ME.

Common name: Mung bean

Scientific name: Phaseolus aureus

Description: Mung bean is a good source of protein (27%) (Mubarak, 2005). The limiting amino acids are methionine and cystine. To overcome this problem, mung bean should be consumed with other sources of protein (Petterson and Mackintosh, 1994).

Proximate composition: The chemical composition of different cultivars of mung beans (%) (Robinson and Singh, 2001)

	Delta Dalby	**Delta Hrmtg**	**Emerald Dalby**	**Emerald Hrmtg**
DM	88.6	91.3	91.6	89.8
CP	25.2	25.0	25.0	25.4
Fat	3.3	3.3	3.2	3.0
Ash	0.9	1.3	0.8	1.2
GE (MJ/kg)	16.8	16.7	16.8	16.8
Starch	38.2	33.7	37.3	34.1
CF	4.5	4.2	4.3	4.7

The chemical composition of mung bean (% dry weight basis) (Mubarak, 2005)

Components	Raw	Dehulling	Soaking	Germination	Boiling	Autoclaving	Microwave cooking
Moisture	9.7	10.1	10.5	11.1	10.1	10.1	10.1
CP	27.5	27.6	27.0	30.0	26.8	26.6	26.7
Crude fat	1.8	1.8	1.8	1.4	1.8	1.8	1.8
CF	4.6	4.1	4.4	4.4	4.5	4.6	4.6
Ash	3.8	3.6	3.3	3.5	3.5	3.5	3.6
Total Carbohydrate*	62.3	62.9	63.4	61.7	63.3	63.4	63.2
Reducing sugars	4.8	4.4	3.8	3.1	3.2	3.3	3.3
Raffinose	0.4	0.3	0.3	0	0.2	0.2	0.3
Stachyose	1.5	1.2	1.2	0	1.1	1.0	1.0
Starch	54.9	54.8	54.7	50.1	54.6	54.6	54.5

* *by difference.*

Minerals: Lestuenne et al. (2005) reported that Fe and Zn content of mung bean 7.17 and 2.81 mg/100g DM.

The mineral content of mung beans (mg/100g dry weight basis) (Mubarak, 2005)

Components	Raw	Dehulling	Soaking	Germination	Boiling	Autoclaving	Microwave cooking
Na	12.0	10.2	9.6	11.6	8.2	8.9	8.1
K	3.6	2.9	2.3	3.9	2.9	2.9	2.8
Ca	84.0	80.0	81.0	88.5	75.0	80.0	78.0
P	391.0	385.0	381.0	406.0	368.0	370.0	365.0
Mg	55.6	54.3	49.9	56.6	44.0	48.0	47.8
Fe	9.7	8.6	8.4	9.6	7.9	8.1	8.0
Mn	1.7	1.5	1.4	1.7	1.3	1.5	1.4

Amino acids: The amino acid content of mung beans (%) (Robinson and Singh, 2001)

	Delta Dalby	Delta Hrmtg	Emerald Dalby	Emerald Hrmtg
Ala	0.9	0.9	0.9	0.9
Arg	1.6	1.6	1.6	1.5
Asp	2.4	2.3	2.3	2.2
Cys	0.2	0.2	0.2	0.2
Glu	2.7	3.4	3.4	3.4
Gly	0.8	0.8	0.8	0.8
His	0.6	0.6	0.6	0.6
Ile	0.9	0.9	0.9	0.9
Leu	1.7	1.7	1.6	1.7
Lys	1.5	1.5	1.5	1.5
Meth	0.3	0.3	0.3	0.3
Phe	1.3	1.3	1.3	1.3
Pro	1.4	1.3	1.3	1.3
Ser	1.1	1.1	1.1	1.1
Thr	0.7	0.7	0.7	0.7

Try	0.3	0.3	0.3	0.4
Tyr	0.6	0.6	0.6	0.6
Val	1.1	1.0	1.1	1.0
Met + Cys	0.5	0.5	0.5	0.5
Phe + Tyr	1.9	1.9	1.9	1.9

The amino acid content of mung bean seeds (g/16 gN) (Mubarak, 2005)

Components	Raw	Dehulling	Soaking	Germination	Boiling	Autoclaving	Microwave cooking
Tyr	3.27	3.27	3.11	3.28	3.23	3.14	3.20
Phe	5.66	5.68	5.60	5.70	5.67	5.69	5.65
Thr	3.15	3.19	3.10	3.20	3.20	3.17	3.18
Cys	0.75	0.76	0.64	0.77	0.76	0.65	0.75
Meth	1.92	1.92	1.70	1.95	1.83	1.85	1.80
Leu	8.36	8.40	8.25	8.53	8.44	8.50	8.43
Ile	4.74	4.70	4.64	4.70	4.40	4.30	4.37
Lys	4.19	4.21	4.15	4.26	4.05	4.00	4.02
Val	5.20	5.21	5.23	5.20	5.20	5.30	5.18
Try	0.97	0.97	0.95	1.00	0.89	0.94	0.88
Asp	13.5	13.5	13.8	13.5	13.8	13.8	13.9
Glu	21.7	21.6	21.6	21.5	21.8	21.7	21.8
Pro	4.23	4.22	4.35	4.20	4.36	4.26	4.37
Ser	4.95	4.95	4.96	4.80	4.90	4.86	4.96
Gly	4.26	4.25	4.35	4.20	4.40	4.38	4.47
Ala	4.35	4.33	4.53	4.41	4.58	4.50	4.66
Arg	6.33	6.33	6.50	6.35	6.00	6.52	5.92
His	2.49	2.50	2.58	2.42	2.54	2.54	2.55

Anti-nutritional factor: Tannins, protease inhibitors and lectins (Wiryawan et al., 1997).

The antinutritional factors of mung bean seeds (Mubarak, 2005)

Components	Raw	Dehulling	Soaking	Germination	Boiling	Autoclaving	Microwave cooking
Trypsin inhibitor (TIU1/mg protein)	15.8	14.6	13.3	12.3	0	0	0
% Reduction		7.59	15.8	22.4	100	100	100
Heamagglutinin activity (HU2/g sample)	2670	1800	1360	560	0	0	0
% Reduction		32.6	49.1	79.0	100	100	100
Tannins (mg/g sample)	3.30	2.20	2.00	1.90	1.80	1.60	1.25
% Reduction		33.3	39.4	66.7	45.5	51.5	62.1
Phytic acid (mg/mg sample)	5.80	4.60	4.30	4.03	4.25	4.41	4.29
% Reduction		20.7	26.7	30.5	25.86	24.0	26.0

1TIU=Trypsin inhibitor units; 2HU=Hemagglutinin units.

AME and digestibility: The AME (MJ/kg) content of mung bean (cv. Delta and Emerald) was 12.34 and 12.48 respectively (Robinson and Singh, 2001). The ME of mung bean was 10.5 MJ/kg DM (Gohl, 1981).

DE and digestibility: DE: The DE content was 15-16 MJ/kg for mung bean (Takken, 1986); 16.09 MJ/kg DM for raw mung bean for pigs (Wiryawan et al., 1997). Apparent ideal digestible energy of raw and steamed mung bean for pigs was 15.38 and 15.91 MJ/kg DM (Yin et al., 1993).

The apparent ideal digestibility of mung beans (Yin et al., 1993)

	DM	OM	GE	ADF	NDF	ADL	CP
Raw (%)	86	88	86	25	64	32	74
Steamed*(%)	90	92	89	-	-	-	80

**Steamed at 0.1 Mpa for 30 min in an autoclave.*

The apparent ideal digestibility of amino acids of mung beans (Yin et al., 1993)

	Raw (%)	Steamed*(%)
Thr	78	77
Val	77	79
Met	63	77
Ile	69	74
Leu	80	80
Phe	76	85
His	76	82
Lys	73	89
Arg	70	88
Asp	82	86
Ser	86	86
Glu	86	89
Pro	67	79
Gly	63	80
Ala	73	76
Tyr	-	74

**Steamed at 0.1 Mpa for 30 min in an autoclave.*

Inclusion in diets:

- Pigs: Takken and Young (1987) and Woltmann et al. (1987) suggested that the levels of incorporation in grower and finisher pig diets should be l00-150g/kg. While Wiryawan et al. (1997) recommended that the inclusion levels of mung bean in finisher pigs can be up to 300 g/kg.
- Poultry: Robinson and Singh (2001) reported that 10-30% mung bean inclusion in layer diets were suitable.

Common name: Coconut and by-products

Scientific name: Cocos nucifera

Description: The coconut is an edible fruit of the coco palm tree (Cocos nucifera). A single tree yields thousands of coconuts over its approximately 70-year of life. Each coconut has several layers: a smooth and deep tan outer covering; a brown fiber of 1-2 inches thickness; a hard and dark brown hairy husk with three indented “eyes” at one end; a thin brown skin; the cream white coconut meat; and a thin opaque

coconut juice at the centre. Nutritional value of coconut varies according to its stage of development. The mature coconut is a good source of iron. Approximately 86% of the calories in coconuts are from fat, most of which is saturated fat but no cholesterol(http://sarasota.extension.ufl.edu/FCS/FlaFoodFare/Coconut.htm). Coconuts produce two by-products. One is coconut oil meal, coconut cake or copra meal, which is the by-product of the extraction of the oil from the coconut seed. This is approximately 34 to 42% of the weight of nut (Hutagalung, 1981). The other is broken kernel, known as raw copra. Copra meal is an excellent source of energy for pigs (O'Doherty and McKeon, 2000). Depending on the milling equipment, the oil residue of the products ranges from 1 to 22%. When coconut cake or meal is used to feed livestock it must not be old and rancid as it will cause diarrhoea (Animal Feed Resources Information System).

Proximate composition: The chemical composition of coconut products

	DM	Ash	CP	EE	CF	SC	Starch	NDF	ADF	GE (MJ/kg)	Lys (g/ 16g N)
Coconut cake 1a (% DM)	89.1	6.1	22.3	8.4	12.0	15.0				19.14	2.9
Coconut cake 2 a (% DM)	90.2	5.9	22.3	7.8	11.7	15.1				19.57	2.6
Coconut cake 3 a (% DM)	94.4	6.6	21.3	13.3	13.7	9.7	9.9	43.9	24.2	21.08	2.5
Coconut kernelb (% fresh)	52.4	1.0	3.7	31.7	1.5						
Copra meal-kernelb (% fresh)	89.4	5.1	19.2	11.7	8.8						

SC=soluble carbohydrate; a Lekule et al., 1990; b Anon. 2005;

The chemical composition of coconut meal (% DM)

	Copra meala	Copra mealb	Copra mealc	Copra meald
DM	-	88.2	92.0	89.9
OM	92.2	-	-	-
CP	19.8	23.2	24.9	20.9
NFE	-	-	-	46.2
EE	8.4	10.5	-	5.8
Crude fat	-	-	24.0	-
CF	-	-	8.3	10.5
NDF	56.3	55.9	-	-
ADF	30.1	-	-	-
Lignin	5.1	-	-	-
Hemicellulose	26.2	-	-	-
Cellulose	25.0	-	-	-
Ash	7.8	7.0	8.3	6.5
GE	-	18.3 (MJ/kg DM)	-	17.6 (MJ/kg)

a Nhut Xuan Dung et al., 2002; b O'Doherty and McKeon, 2000; c Panigrahi et al., 1987. d Creswell and Brooks, 1971 (note the value is a percentage; not clear on which basis such as fed or DM basis).

Minerals: Ca content was 0.08% and P content was 0.62% for Copra meal (Panigrahi et al., 1987). Ca and P content were 0.01% and 0.03% for coconut kernel and 0.05% and 0.49% for copra meal (kernel) on fresh matter basis (Anon. 2005).

The mineral content of copra meal

Mineral*	Composition
Dry matter (%)	89.90
Calcium (%)	0.16
Phosphorus (%)	0.55
Magnesium (%)	0.23
Potassium (%)	1.75
Zinc (mg/kg)	53.0
Copper (mg/kg)	40.0
Manganese (mg/kg)	75.0

**Creswell and Brooks, 1971*

Amino acids: Lysine content of the copra meal is 0.54% (O'Doherty and McKeon, 2000) and 0.75% (Panigrahi et al., 1987); and methionine and cystine of the copra meal is 0.77% (Panigrahi et al., 1987).

The amino acid content of copra meal

Amino acid	Copra meal[1] (% as fed)	Coconut meal[2] (% as fed)
DM	89.90	-
Alanine	0.81	-
Valine	0.89	0.91
Glycine	0.89	0.82
Isoleucine	0.60	0.63
Leucine	1.21	1.18
Proline	0.71	-
Threonine	0.66	0.58
Serine	0.96	0.79
Methionine	0.37	0.28
Hydroxyproline	0.05	-
Phenylaline	0.81	0.88
Aspartic acid	1.62	-
Glutamic acid	3.64	-
Tyrosine	0.46	0.44
Lysine	0.48	0.50
Histidine	0.41	0.36
Arginine	1.96	1.97
Cystine (1+2)	0.24	0.28
Trp		0.12

1Creswell and Brooks, 1971; 2 Say, 2002.

Anti-nutritional factor: Antioxidants should be added and Vitamin E levels monitored. No anti-nutritive factors, but the product should be introduced and removed slowly (Ewing, 1997).

AME and digestibility: The AME of coconut meal (extraction and expeller) was 6.2 and 5.8 MJ/kg (Ewing, 1997). ME of coconut kernel and copra meal (kernel) were 12.9 and 11.9 MJ/kg on fresh matter basis respectively (Anon. 2005). ME of coconut oilcake (8% EE, 13% EE and extracted) 11.7, 13.7 and 6.9 respectively (Gohl, 1981).

DE and digestibility: DE of coconut kernel and copra meal (kernel) were 16.2 and 12.8 MJ/kg on fresh matter basis respectively (Anon. 2005).

The digestibility (%) and ME (MJ/kg DM) of coconut cake (Lekule et al., 1990)

	Coconut cake [1]	**Coconut cake [2]**	**Coconut cake [3]**
DM	76	71	70
OM	78	73	71
CP	68	57	56
Crude fat	75	75	73
CF	73	67	65
NFE	84	81	80
Energy	75	70	60
ME	13.88	13.20	13.95

The mean digestibility coefficients (%) for organic matter, protein, energy and digestible energy content of copra meal

Copra meal (g/kg) in diet	**DM**	**OM**	**CP**	**NFE**	**EE**	**Energy**	**DE (MJ/kg DM)**	**Source**
200	-	87.9	84.6	-	-	85.5	16.4	O'Doherty and McKeon, 2000
400	-	84.8	74.8	-	-	82.8	15.7	O'Doherty and McKeon, 2000
-	83.7	-	50.7	94.1	100.0	85.4	15.0 (MJ/kg)	Creswell and Brooks, 1971

Inclusion in diets:

- Pigs: Depending on the other ingredients copra meal may constitute up to 25% of the diet for pigs. Thorne et al. (1992) reported inclusion of 10% copra meal resulted in slightly poorer growth rates compared with the control diet, but no further deterioration was observed up to 30% for pigs housed at a constant temperature of 25°C.
- Poultry: The use of copra cakes for growing poultry is limited by their low energy value. However, they may be freely used with layers. Up to 20% of the diet, performances remain comparable with those obtained with standard rations. Thomas and Scott (1962) reported that a properly supplemented starter diet containing 40% copra meal could promote good growth and efficiency of food utilization. Nagura (1964) successfully used a diet containing 42% solvent extracted coconut meal after having balanced the diets for protein and metabolisable energy. But Panigrahi et al. (1987) found that the body weight of chicks fed the 50% copra cake diet were significantly lower than those fed any of the other diets (0, 12.5 and 25% inclusion of copra cake).

Common name: Amaranth

Scientific name: Amaranthus gangeticus

Description: Amaranth is a tall plant with very broad leaves; it produces many thousands of tiny seeds. The leaves and the seeds are edible (http://www.specialfoods.com/amaranth.html). Compared to common cereals such as maize, wheat and rice, amaranth has high content of CP and is relatively rich in lysine, tryptophan and methionine (Bressani et al., 1987).

Proximate composition: Larsen et al. (2003) reported that N content is 4.18 % DM and ash content is 23.8% DM.

The chemical composition of amaranth seeds

	DM	Ash	CP	ADF	NDF	GE (MJ/kg)	EE
K343-black seed1 (%)	90.3	17.4	13.2	28.0	27.0	16.77	
K343-white seed1 (%)	92.1	9.0	16.2	10.2	11.8	18.64	
R158-white seed1 (%)	88.1	3.7	14.2	6.2	10.6	19.70	
477913-black seed1 (%)	89.4	9.4	14.6	24.5	22.2	18.32	
477913-white seed1 (%)	89.6	5.9	15.9	8.2	11.0	14.05	
Amaranth seed2 (%)	91.8		16.8			17.7	5.8

1 Pond et al., 1991; 2 Ravindran et al., 1996;

The chemical composition of amaranth seed (%) (Bressani et al., 1987)

	DM	EE	CP	Ash
A. caudatus (A-713)	88.3	12.5	14.8	2.9
A. caudatus (A-982)	87.9	12.3	12.5	2.6
A. caudatus (A-1113)	88.4	11.5	12.5	3.0
A. hybridus (82S-1004)	86.7	8.5	15.6	5.0
A. cruentus (82S-1011)	88.1	12.8	14.7	2.8
A. cruentus (82S-434)	87.7	10.9	15.1	3.2
A. cruentus (82S-1034)	86.7	9.2	16.0	3.4
A. hypochondriacus (A-718)	87.9	10.4	13.7	3.3
A. hypochondriacus (A-720)	88.1	10.3	14.7	3.9
A. hypochondriacus (82S-1023)	87.2	10.6	15.3	2.9
A. hypochondriacus (82S-1024)	87.1	9.2	14.7	3.9
A. hypochondriacus (82S-674)	86.4	8.2	15.1	3.4
A. hypochondriacus (82S-SP130)	87.2	9.2	15.0	3.3
A. hypochondriacus (82S-1008)	87.6	7.7	15.6	4.0

Minerals: The Ca and P content was 2.9 and 0.62 % for amaranth leaves (Larsen et al., 2003) and 0.22 and 0.56% for amaranth seeds (Ravindran et al., 1996).

The mineral content (%) of amaranth lines (Pond et al., 1991)

Line	Total P	Phytate P	Ca	Mg	K	Na	Fe	Zn
K343-black seed	0.46	0.27	0.41	0.41	0.33	0.009	0.31	0.002
K343-white seed	0.68	0.43	0.27	0.39	0.37	0.005	0.27	0.002
R158-white seed	0.63	0.37	0.26	0.34	0.32	0.004	0.21	0.002
477913-black seed	0.54	0.29	0.43	0.43	0.33	0.006	0.29	0.002
477913-white seed	0.65	0.42	0.25	0.35	0.35	0.005	0.26	0.002

The mineral content of Amaranth seed (mg/100g) (Bressani et al., 1987)

	P	K	Ca	Mg	Na	Fe	Cu	Mn	Zn
A. caudatus (A-713)	518	493	246	396	19	20	0.85	3.39	3.40
A. caudatus (A-982)	594	532	201	270	22	15	0.87	2.62	3.49
A. caudatus (A-1113)	597	571	205	290	24	28	0.85	2.56	3.41
A. hybridus (82S-1004)	565	532	303	344	26	104	4.1	5.18	3.45
A. cruentus (82S-1011)	589	545	202	334	24	17	1.68	2.51	4.19
A. cruentus (82S-434)	544	518	263	311	24	34	1.69	3.38	4.22

A. cruentus (82S-1034)	536	511	260	386	27	27	1.71	4.27	4.27
A. hypochondriacus (A-718)	625	549	287	372	25	30	1.63	3.28	4.10
A. hypochondriacus (A-720)	667	556	256	368	26	100	3.51	4.39	4.39
A. hypochondriacus (82S-1023)	586	570	204	323	24	22	1.70	2.55	4.12
A. hypochondriacus (82S-1024)	556	590	222	333	24	55	2.56	4.27	3.42
A. hypochondriacus (82S-674)	589	538	308	359	22	26	1.71	3.42	3.42
A. hypochondriacus (82S-SP130)	576	516	206	309	22	31	1.72	2.58	3.43
A. hypochondriacus (82S-1008)	605	621	223	327	22	111	3.98	3.98	3.98

Amino acids: The amino acid content (%) of amaranth lines* (Pond et al., 1991)

	K343-black seed	**K343-white seed**	**R158-white seed**	**477913-black seed**	**477913-white seed**
Asp	1.25	1.44	1.41	1.53	1.45
Glu	2.24	2.90	2.76	2.81	2.93
Ser	1.26	1.12	1.12	1.39	1.15
His	0.35	0.42	0.42	0.46	0.44
Gly	1.25	1.28	1.31	1.44	1.30
Thr	0.54	0.65	0.64	0.64	0.65
Arg	1.39	1.72	1.66	1.61	1.78
Ala	0.54	0.69	0.65	0.63	0.68
Tyr	0.51	0.62	0.60	0.54	0.66
Val	0.51	0.67	0.63	0.64	0.68
Phe	0.56	0.74	0.68	0.63	0.73
Ile	0.47	0.62	0.57	0.57	0.63
Leu	0.87	1.05	1.04	0.96	1.04
Lys	0.74	0.97	0.96	0.88	0.97

**Tryptophan destroyed by acid hydrolysis; S-containing amino acids unreliable.*

Anti-nutritional factor: Phenolics (primarily tannins and chlorogenic acid; Becker et al., 1981; Lorenz and Wright, 1984), lectins (Koeppe and Rupno, 1988), trypsin inhibitors (Koeppe et al., 1985) and possibly saponins (Khoda et al., 1991) in amaranth grains.

AME and digestibility: The AME (MJ/kg DM) values of raw and autoclaved (under steam at 130°C for 1 hour and drying for 24 h at 60°C in a forced-draft oven) amaranth were 11.85 and 13.11 respectively (Ravindran et al., 1996).

DE and digestibility:

Inclusion in diets: Ravindran et al. (1996) reported that amaranth could be incorporated in broiler diets at levels up to 400g/kg without adverse effects on performance.

Common name: Pigeon pea leaves

Scientific name: Cajanus Cajan

Description: Pigeon pea is a high-yielding tropical legume with the record forage yield of 51-57 t/ha. Stems comprise of over 50% of the total yield. Seed yields of up to 7 t/ha.

Proximate composition: The chemical composition of pigeon pea leaves and branches

	Leaves and branches1 (%DM)	Leaves (first cut)2-fresh (%DM)	Leaves (first cut)2-hay (%DM)	Leaves (cut at 4 weeks)3 (%DM)	Leaves (cut at 6 weeks)3 (%DM)	Leaves (cut at 8 weeks)3 (%DM)
DM		40.2	93.1			
CP	15.2	31.6	29.4	23.3	21.9	20.1
EE				5.2	5.1	4.8
CF				24.8	26.1	27.1
Cell wall		59.2	51.0			
NDF	63.1					
ADF	46.5					
ADL	19					
Acid detergent residue		27.2	34.7			
Crude lipid	2.3					
Ash		5.2	6.8	5.7	5.6	5.5
OM	95.5					

1Berardo et al., 1997; 2 Brown and Chavalimu 1985; 3Udedibie and Igwe, 1989;

Minerals: Ca and P content of pigeon pea leaves cut at 4, 6 and 8 weeks were 1.4, 0.3; 1.2, 0.2 and 1.1, 0.2% DM respectively (Udedibie and Igwe, 1989).

Amino acids:

Anti-nutritional factor:

AME and digestibility:

DE and digestibility:

Inclusion in diets:

- Pigs:
- Poultry: Up to 7.5% pigeon pea leaf meal inclusion in diets did not adversely affect layer performance, but 10% was needed to give a yolk colour score of 8 on the Roche colour fan in white maize-based layers' diets. At levels over 20%, pigeon pea leaf meal depressed feed intake and egg production (Udedibie and Igwe, 1989).

Common name: Cassava

Description: The cassava plant is a shrubby, woody, short-lived perennial growing to a height of 3 m or more, with erect stems and varying degrees of branching. Roots, stem and forage (leaf 45%, petiole 25% and tender stem 30%) composite of the whole cassava plant. While Ravindran (1993) reported roots composite 45%, stem 35% and forage 20% of whole plant. Cassava leaves are a good source of protein with average CP content of 21%, high in lysine, but deficient in methionine (Eggum, 1970). The potential yields of cassava leaves as by-product at root harvesting may produce as much as 4.64 tonnes dry matter per hectare (Ravindran and Rajaguru, 1988). Cassava leaves are a good source of minerals, particularly Ca, Mg, Fe, Mn and Zn (Ravindran and Rajaguru, 1988). The traditional processing of cassava leaves is by drying or boiling, but considerable losses of vitamins, particularly of ascorbic acid during the processing (Ravindran, 1992). Because cassava can contain high levels of cyanogenic glycosides, it must be processed prior to use (Say, 2002). The successful use of cassava root meal as a substitute for maize, diets must be

supplemented with methionine, particularly when soybean meal used as the main protein supplement (Say, 2002).

Proximate composition:

The chemical composition of cassava root meal (% as fed) (Stevenson and Graham, 1983)

	DM	Ash	Insol. ash	CP	EE	Starch	CF
Native cassava1	88.9	5.8	3.1	2.7	0.4	69.6	4.9
Native cassava2	89.2	6.3	3.9	2.4	0.5	60.5	4.3
Native cassava3	88.8	5.8	3.3	2.6	0.3	64.1	4.9
Native cassava4	89.0	5.3	3.2	2.3	0.3	62.0	5.0
Native cassava5	89.3	6.4	3.9	2.3	0.3	62.9	4.5
Native cassava6	89.2	5.6	3.4	2.3	0.2	61.4	4.8
Native cassava7	87.3	4.0	1.8	2.2	0.3	62.6	3.3
Pelleted Cassava 1	88.8	5.6	3.1	2.4	0.4	62.3	3.7
Pelleted Cassava 2	89.3	6.0	3.4	2.4	0.4	61.2	3.4
Pelleted Cassava 3	89.3	5.8	3.5	2.5	0.4	60.9	3.4

	DM	CP	EE	CF	Soluble carbo-hydrate	Starch	NDF	ADF	Ash	GE (MJ/kg DM)	Source
Cassava meal (% as fed basis)	87.6	1.2	0.6	13.4					1.5		
Cassava meal 1 (% DM)	88.0	4.3	1.4	4.2					5.8	16.76	Lekule et al., 1990
Cassava meal 2 (% DM)	87.4	2.8	1.3	3.6	81.1	78.6	7.0	5.3	5.7	16.22	
Cassava meal 3 (% DM)	88.0	4.6	1.2	5.6	72.2		9.0	7.8	7.1	16.77	
Cassava meal 4 (% DM)	87.7	2.8	1.0	3.6	80.6	78.3	6.4	4.9	7.1	15.94	
Cassava meal 5 (% DM)	87.2	3.3	0.9	4.9	74.4	70.1		5.9	6.0	16.67	
Cassava leaves (KM94, % DM)		34.7	13.3	12.0					6.2		Phuc et al., 1996
Cassava leaves (India, % DM)		31.0	14.1	11.7					7.8		
Cassava leaves (Gon, % DM)		28.5	13.5	14.6					7.9		
Cassava leaves (Japan, % DM)		27.1	14.6	10.1					6.1		
Cassava leaves (KM60, % DM)		25.4	14.4	9.7					5.0		
Cassava leaves (KM95, % DM)		23.9	15.6	10.7					5.9		

Cassava root meal (% fresh)	36.6	0.8	0.4	1.3					0.9		Anon. 2005
Cassava leaf meal (% fresh)	16.4	4.1	1.0	3.2					1.4		

Minerals: The mineral content of cassava products

	Ca	P
Cassava root meal1 (% fresh)	0.06	0.07
Cassava leaf meal1 (% fresh)	0.18	0.10

1 Anon. 2005

The mineral content of cassava root meal (% as fed) (Stevenson and Graham, 1983)

	Cl	Na	Ca	P	K
Native cassava1	0.02	0.012	0.27	0.084	0.915
Native cassava2	0.018	0.012	0.26	0.084	0.78
Native cassava3	0.02	0.012	0.28	0.084	0.875
Native cassava4	0.022	0.014	0.24	0.075	0.755
Native cassava5	0.020	0.014	0.26	0.082	0.805
Native cassava6	0.022	0.013	0.26	0.075	0.71
Native cassava7	0.018	0.014	0.16	0.074	0.78
Pelleted Cassava 1	0.018	0.01	0.22	0.084	0.875
Pelleted Cassava 2	0.032	0.022	0.24	0.086	0.73
Pelleted Cassava 3	0.034	0.021	0.22	0.089	0.715

Amino acids:

	Cassava leaf meal2 (g/16 N)
Arg	5.3
Lys	5.9
Meth	1.9
Cys	1.4
Total sulphur amino acids	3.3
Try	2.0
His	2.3
Ile	4.5
Leu	8.2
Phe	5.4
Thr	4.4
Val	5.6
Tre	

1 Eggum 1970;

Anti-nutritional factor: Cassava roots must be processed very carefully as they contain a glucoside, linimarin, which is acted upon by an enzyme to liberate prussic acid. The peeled roots contain much less prussic acid than unpeeled roots because most of the prussic acid is in the skin (Gohl, 1981).

The HCN content of some varieties of cassava leaves (Phuc et al., 1996)

Varieties of cassava	HCN (before sun-drying ppm DM)	HCN (after sun-drying ppm DM)
KM94	509	86.3
India	411	57.6
Gon	285	17.0
Japan	347	57.1
KM 60	490	23.0
KM 95	360	20.2

The hydrocyanic acid content (ppm DM) of cassava leaf meal as influenced by processing (Ravindran et al., 1986)

Wilting (days)	Sun-drying	
	Full leaves1	Chopped leaves2
0	173	109
1	141	88
2	114	72
3	93	53

1 Freshly harvested cassava leaves contained 1436 mg HCN/kg DM; 2 Freshly chopped cassava leaves contained 1045 mg HCN/kg DM.

AME and digestibility: The ME (MJ/kg) content of cassava leaf meal was 7.5 for poultry (Ravindran, 1993). The TMEn content of 7 native cassava root meals was 14.06, 12.95, 12.81, 12.71, 14.23, 13.26 and 14.13 MJ/kg as fed basis. The TMEn content of 3 pelleted cassava root meals was 13.41, 13.47 and 13.50 MJ/kg as fed basis (Stevenson and Graham, 1983). ME content of fresh cassava root meal was 4.57 MJ/kg (Anon. 2005). ME content of cassava tuber was 14.7 MJ/kg DM (Gohl, 1981).

DE and digestibility: The ME (MJ/kg) content of cassava leaf meal was 9.0 for pigs (Ravindran, 1993). DE content of fresh cassava root meal was 4.71 MJ/kg (Anon. 2005).

The digestibility (%) and ME (MJ/kg DM) of cassava meal (Lekule et al., 1990)

	Cassava meal 1	Cassava meal 2	Cassava meal 3	Cassava meal 4	Cassava meal 5
DM	84	85	82	86	87
OM	89	91	89	92	91
CP	52	49	54	32	54
Crude fat	26	30	15	26	26
CF	38	52	40	53	42
NFE	95	97	96	97	97
Energy	86	88	86	90	90
ME	14.24	14.24	14.24	14.32	14.32

Inclusion in diets:

- Pigs: Pigs were reluctant to consume all ensiled cassava leaves, especially when this was at high levels in the diet (75 or 100 g/day of protein). While Alhassan and Odoi (1982) reported that linear depression in weight gain and feed efficiency when cassava leaf meals were included at up to 30% in the diets of growing-finishing pigs. Phuc et al. (1996) reported that both ensiled cassava leaves and sun-dried cassava leaf meal can be used to substitute up to 30% of the dietary protein in diets based on cassava root meal with no significant effect on nitrogen retention, although diet DM digestibility was slightly reduced.
- Poultry: Fifteen percent cassava leaf meal (oven dried 60°C) can be included in a broiler diet. Akinfala et al. (2002) reported that sun-dried whole cassava plant meal can be included up to 12.5% to 25% of a broilers 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., 1986). Sonaiya 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 on 12.5% cassava plant meal diets.

Common name: Papaya or pawpaw

Scientific name: Carica papaya

Description: Pawpaw is fast growing tree with deeply lobed leaves that cluster at the top of the trunk (Gohl, 1981). Green papaya is a popular vegetable for making curry and the ripe papaya is eaten as fruit. The papaya seeds and skin can be used as poultry feed. Seeds account for about 14.3% (Chan et al., 1978) and about 15% (Marfo et al., 1986) of the weight of fresh papaya. The skin constitutes about 21% of the weight of fresh green papaya (Fouzder et al., 1999). The energy value of fresh green papaya is 1.5 MJ/kg and it contains 9g CP, 64 g carbohydrate, 8 g fat, 130 mg Ca, 9 mg Fe, 0.4 mg vitamin B1, 0.2 mg vitamin B2, 5.6 g carotene and 60 mg vitamin C per kg edible part (Haque, 1985). The fruits, supplemented with concentrates are good source feed for pigs (Gohl, 1981).

Proximate composition: Papaya fruit contains 77.8% of moisture, 2.6% of total dietary fibre, 1.3% of insoluble dietary fibre, 1.3% of soluble dietary fibre (Ramulu and Rao, 2003) and 0.8% of crude fibre (Gopalan et al., 2000).

The chemical composition of papaya products

	Skin1 (% DM)	Skin2 (% DM)	Detestaed, undefatted seed3 (%)	Detestaed, defatted seed3 (% dry weight)	Leaves4 (% fresh)	Fresh leaves5 (% DM)	Fresh leaves5 (% DM)	Dried leaves5 (% DM)	Whole fruit, early vegetative5 (% DM)	Whole fruit, mature5 (% DM)
DM	87.4	91	93.8	99.7	22.0	19.5	24.6	92.5	7.2	9.1
CP	22.9	25.2	27.8	0.2	5.9	20.9	32.6	23.5	11.4	11.1
EE	3.7	2.1	28.3	44.4	1.5	13.6	0.8	4.2	0.8	1.2
CF	12.2	6.7	22.6	31.8	2.4	14.5	7.3	10.6	12.5	11.7
Lignin				1.5						
Ash	11.4	1.0	3.5	4.5	2.9	15.4	11.0	12.3	7.4	9.4
NFE	49.8					35.6	48.3	49.4	67.9	66.6

1 Fouzder et al., 1999; 2 Kamaruzzaman et al., 2005; 3Marfo et al., 1986; 4 Anon, 2005; 5 Gohl, 1981.

Minerals: Ca and P content of papaya leaves were 0.52% and 0.05% (on fresh matter basis) (Anon, 2005). Ca and P content of fresh papaya leaves and whole fruit (mature, Trinidad) were 2.4 and 0.2 % of DM and 0.23% and 0.16% respectively (Gohl, 1981).

The mineral content of detestaed papaya seed

	Detestaed papaya seed1 (ug/g)	Papaya fruit2 (edible part) (ppm)
Cu	50	0.16
Mg	220	100
Fe	130	1.0
Ca	17340	240
S	520	
Ni	10	
Co	4	
Mn	3	0.11
K	340	2570
Na	110	30
P	10250	50
Zn		0.7
Se		6

1Marfo et al., 1986; 2 http://www.thefruitpages.com/chartpapaya.shtml

Amino acids: The amino acid content of papaya products

	Papaya skin1 (% DM)	Papaya fruit2 (edible part) (%)
Asp	2.7	0.049
Glu	1.5	0.033
Ser	0.6	0.015
Gly	3.1	0.018
Thr	0.4	0.011
Arg	0.5	0.01
Ala	0.6	0.014
Tyr	0.3	0.005
Try	0.02	0.008
Val	0.5	0.01
Phe	0.4	0.009
Ile	0.4	0.008
Leu	0.8	0.016
Lys	0.8	0.025
Meth		0.002
His		0.005
Pro		0.01

1 Kamaruzzaman et al., 2005;

Anti-nutritional factor: The contents of phytates, Glucosinolates and tannins were 3.04, 10.0 and 6.35 % of dry weight of dehulled and defatted papaya seed meal (Marfo et al., 1986).

AME and digestibility: NA

DE and digestibility: NA

Inclusion in diets:

- Pigs: Papaya leaves are useful in elevating mineral/vitamin status of village fed pigs. Papaya fruit are good source of essential vitamins and minerals for village fed pigs (Anon. 2005).
- Poultry: Kamaruzzaman et al. (2005) concluded that dried papaya skin could safely be used up to 120g/kg in the diet of broiler chicken.

Common name: Pigeon pea

Description: The pigeon pea is a shrub that grows from one to a few meters tall and perhaps a couple meters wide, but it depends on the varieties. Pigeon pea has relative high protein contents; leaves also can be used for animal feed (Price, 1998). When used as a "vegetable", the pea is picked when the seeds have reached physiological maturity, that is, when they are fully grown but just before they lose their green color. At this stage the green seed is more nutritious than the dry seed because it has more protein, sugar and fat (Price, 1998).

Proximate composition:

The effects of processing on chemical composition of pigeon pea (% wet weight) (Igbedioh et al., 1994)

	CP	Ash	Crude fat	Moisture	CF	Carbohydrate
Raw seed	20.0	3.6	1.5	11.0	4.3	59.4
Soaking	20.3	3.6	1.5	16.1	4.3	54.2
Sprouting	21.3	3.6	0.8	4.5	4.5	61.0
Roasting						
15	12.2	3.3	1.2	10.1	2.1	73.2
30	9.3	3.0	0.8	3.8	2.0	81.2
45	9.2	3	0.8	3.5	2.0	81.6
Autoclaving	13.7	3.1	0.9	10.3	4.2	69.1

The chemical composition of raw and autoclaved (at 2.109 kg/cm2 for 30 min. dried at 85ºC for 24 h) white and brown varieties of pigeon pea

	DM	CP	EE	Ash	CF	NFE	GE(MJ/kg)	Source
White, raw (% as feed basis)	90.5	16.6	3.6	3.9	5.5	60.8	16.6	Nwokolo and Oji, 1985
Brown, raw (% as feed basis)	89.3	21.3	3.0	4.9	6.0	54.0	16.2	
White autoclaved (% as feed basis)	90.4	16.8	3.1	3.4	5.2	61.8	16.8	
Brown autoclaved (% as feed basis)	89.3	22.2	3.2	3.9	5.5	54.5	16.9	
Pigeon pea raw (% dry weight)		21.9	2.7	4.6	8.3	62.6	15.1	Oloyo, 2004
Pigeon pea (%)	91.2	19.1	1.9	3.2	3.5	63.5		Apata and Ologhobo, 1994

The chemical composition of green and mature pigeon peas (dry weight basis) (Price, 1998)

Composition	Green seed	Mature seed
CP (%)	21.0	18.8
Starch (%)	44.8	53.0

Soluble sugars	5.1	3.1
Flatulence factors (% sol.sugar)	10.3	53.5
CF (%)	8.2	6.6
Fat (%)	2.3	1.9

Minerals:

	Fe	Mn	Ca	Mg	Cu	P	Zn
Pigeon pea1(mg/100g dry weight)	5.5	2.9	140	88.9	1.1	290	-
Green seed2 (mg/100g)	4.6	-	94.6	113.7	1.4	-	2.5
Mature seed2 (mg/100g)	3.9	-	120.8	122.0	1.3	-	2.3
Pigeon pea3 (ppm)	43.8	19.1	1130	1500	11.4	3900	35.1

1 Oloyo, 2004; 2 Price, 1998; 3Apata and Ologhobo, 1994;

Amino acids: The amino acid content of pigeon pea

	Pigeon pea1 (%)	Pigeon pea2 (%)
Arg	1.3	1.2
Asp	2.1	1.8
Cys	0.2	0.2
Glu	3.5	3.2
Gly	0.8	0.7
His	0.6	0.7
Ile	0.8	0.7
Leu	1.6	1.4
Lys	1.4	1.3
Meth	0.3	0.2
Phe	1.8	1.6
Pro	0.8	0.8
Ser	0.9	0.9
Thr	0.8	0.7
Try	0.2	-
Tyr	0.8	0.5
Val	1.0	0.8
Ala	1.3	1.1

1Apata and Ologhobo, 1994; 2 Petterson and Mackintosh, 1994;

Anti-nutritional factor: Trypsin inhibitor (units/mg) of green pigeon pea seed was 2.8 and mature seed was 9.9. Amylase inhibitor (units/mg) for green pigeon pea was 17.3 and for mature seed was 26.9 (Price, 1998).

The anti-nutritional factor content of pigeon pea

	Total oxalate (%)	Tannins (mg/100g)	Total phenolics (ug/100g)	Trypsin inhibitory activity*	Phytic acid (mg/100g)
Pigeon pea1(mg/100g dry weight)	15.4	2.2	22.8	15.4	811

*1 Oloyo, 2004; * Expressed as units of enzyme activity inhibited per mg protein;*

The effects of different processing on phytic acid content of pigeon pea (mg/100g) (Igbedioh et al., 1994)

	Phytate
Raw seed	220
Soaked and sprouted	154
Soaked, dehulled and sprouted	147
Boiling of sprouts	103
Autoclaving of unsoaked seed	161
Autoclaving of soaked seed	154
Autoclaving of soaked and dehulled seed	141

AME and digestibility: AME of pigeon pea (white, raw; brown, raw; white autoclaved and brown autoclaved) was 12.4, 12.2, 13.1 and 13.1 MJ/kg respectively (Nwokolo and Oji, 1985).

DE and digestibility: DE (estimated MJ/kg DM) of pigeon pea for swine was 16.2 (Oloyo, 2004).

The digestibility and ME of pigeon pea (Gohl, 1981)

Pigeon pea	CP	CF	EE	NFE	ME (MJ/kg DM)
Dried	84.8	48.8	57.3	81.6	12.2
Fresh	92.0	86.0	36.0	86.0	14.8

Inclusion in diets:

Up to 30% has been included in the starting chicken ration with the same weight gain obtained from an isonitrogenous mixture of soybean oil meal and maize (Gohl, 1981).

Common name: Leucaena leaf meal

Scientific name: Leucaena leucocephala

Description: The leaf meal from leguminous shrubs and trees contains relatively high crude protein, high fibre and low energy. Preparation of leaf meal normally involves the pruning of shrubs and the drying of branches on concrete floors in the sun. With Leucaena Leucocephala the dried leaves are readily harvested by threshing. Leaf meals with the moisture content reduced to around 120g/kg, may be stored for prolonged periods without significant deterioration in quality (D'Mello, 1995). D'Mello and Taplin (1978) reported that L. Leucocephala (Lam.) leaf meal had high β-carotene (227 to 248 mg/kg DM) and xanthophylls (741 to 766 total xanthophylls per kg) content. The concentration of carotenoids in leaf meals will depend upon the duration and method of drying. Rapid sun-drying of L. Leucocephala foliage produced high carotene and xanthophyll content of 484 and 932 mg/kg DM respectively (Wood et al., 1983). However, substantial losses occurred during oven-drying at 60°C and 145°C. Monthly losses of carotenes and xanthophylls during storage of the leaf meal were of the order of 19 to 40 mg/kg and 29 to 53 mg/kg respectively. Pelleting or the addition of an anti-oxidant failed to arrest these losses during processing or storage (D'Mello, 1995). The major constraints are the intrinsic low digestibility of the protein fraction and the inferior metabolisable energy content relative to that of the legume grains (D'Mello, 1992). The attempts to enhance the nutritional value of diets containing L. leucocephala leaf meal have consisted of the use of iron and aluminium salts as supplements. D'Mello and Acamovic (1982b) reported that addition of crystalline FeSO4 during blending of dietary components was sufficient to increase mimosine output in the excreta of chicks and Al2(SO4)3.16H2O supplementation promoted total excretion of all mimosine ingested by chicks. It is believed that tannins bind more strongly to polyethylene glycol than

they do to proteins. Hewitt and Ford (1982) concluded that dietary supplementation with polyethylene glycol (molecular weight 4000) was a simple and cost-effective method of improving the nutritional value of high-tannin feedstuffs without compromising the agronomic benefits conferred by the high tannin content. Leucaena leaf is also good source of protein and calcium (Hussain et al., 1991).

Proximate composition:

The chemical composition of Leucaena Leucocephal (fully expanded leaves harvested from the shoots)

Species	Drying method	DM	CP	EE	CF	Ash	NDF	ADF	ADL	Total condensed tannin (%)
L. Leucocephala 1(%)	Freeze-dried	-	17.6	-	-	-	30.3	19.4	5.9	6.8
L. Leucocephala 1(%)	Oven-dried (65°C)	-	-	-	-	-	33.5	23.6	8.4	-
Leucaena leaf meal 2 (% DM)		89.7	21.3	7.0	11.8	7.9	-	-	-	-
Leucaena leaf meal 3 (% fresh)		30.5	7.4	1.2	5.4	2.1				

1 Balogun et al., 1998; 2 Hussain et al., 1991; 3 Anon. 2005.

Minerals: Ca and P content was 3.1% and 0.17% for leucaena leaf meal (Hussain et al., 1991) and 0.11% and 0.04% respectively (Anon. 2005) for Leucaena leaf meal (fresh matter).

The mineral content of leaf meals

	g/kg					mg/kg			
	Ca	P	Na	K	Mg	Cu	Fe	Zn	Mn
L. leucocephalaa	18.1	2.5	0.0	8.0	5.1	9.9	239.9	21.2	42.1

a D'Mello and Fraser, 1981.

Amino acids: The amino acid content (% DM) of leaf meals

Amino acid	Leucaena leucocephalaa
Threonine	1.21
Glycine	1.33
Valine	1.44
Cysteine	0.20
Methionine	0.46
Isoleucine	1.37
Leucine	2.17
Tyrosine	1.25
Phenylalanine	1.48
Lysine	1.76
Histidine	0.54
Arginine	1.51
Tryptophan	0.38

a D'Mello and Fraser, 1981.

Anti-nutritional factor: L. Leucocephala leaf meal contains a high level of mimosine. The content of minosine and tannins was 3.7% and 0.95% respectively (Calculated

Hussain et al., 1991). D'Mello and Acamovic (1982b) reported that up to 92% of ingested mimosine was excreted by chicks fed the leaf meal.

The anti-nutritional factors of Leucaena leucocephala leaf a

Anti-nutritional factor	Concentration (g/kg DM)
Mimosine	10-120
3-hydroxy-4(1H)-pyridone	5.1-8.2
Tannins	13-44
Trypsin inhibitors	Weak activity
Galactomannan gums	46
Saponins	2-11
Flavonols	30-60
Haemagglutinins	-

a D'Mello and Taplin, 1978 and ter Meulen et al., 1984 (cited by D'Mello and Acamovic, 1989).

AME and digestibility: D'Mello and Acamovic (1982a) reported that the AME of Leucaena leucocephala leaf meals for poultry was 3.4 (MJ/kg DM).

DE and digestibility: The ME of Leucaena leucocephala leaf meal was 5.3 (MJ/kg DM) (Gonzalez Vargas and Wyllie, 1982) for pigs.

Inclusion in diets:

Pigs: Given diets containing L. Leucocephala leaf meal at 100g/kg, grow at faster rates than control animals but liveweight gain declines sharply with diets containing the leaf meal at 500g/kg (Malynicz, 1974). Anon. (2005) reported that inclusion of L. Leucocephala leaf meal in pig diet was 15%.

Poultry: D'Mello et al. (1987) reported that L. Leucocephala leaf meal included at 100 g/kg diet for older broiler chicks markedly reduced the growth of chicks without affecting DM intake. While Meulen et al. (1984) reported that 200g/kg inclusion in diet depressed the performance of chicks and Hussain et al. (1991) reported that inclusion of Leucaena leaf meal up to 150g/kg in the diet did not significantly ($P<0.05$) influence the performance of broilers in terms of body weight gain and feed efficiency.

The performance (g/day) of chicks and pigs fed diets with different levels of L. Leucocephala

		Dietary level of leaf meal (g/kg)						
Leaf meal	Animal	0	100	150	200	300	400	500
L. Leucocephala	Chicksa	24.5	-	-	10.3	-	2.5	-
	Chicksb	24.4	25.9	-	-	-	-	-
	Chicksc	54.8	47.4	-	-	-	-	-
	Pigsd	281	404	-	390	299	218	154

a D'Mello and Acamovic (1982a). b D'Mello and Acamovic (1982b). c D'Mello et al., (1987). d Malynicz, (1974).

Common name: Cabbage

Description: Cabbage is very low in saturated fat acids and cholesterol. It is good source of Vitamin A, B6, thiamine, Ca, iron and Mg. It is also good source of dietary fibre, Vitamin C, Vitamin K, Folate, K and Mn (http://www.nutritiondata.com/gacts-001-02s01tv.html).

Proximate composition:

The chemical composition of cabbages

	Swamp cabbage1 (% fresh)	Cabbage2 (% fresh)
DM	9.2	8.6
CP	3.2	1.6
EE	0.4	0.1
CF	0.9	3.1
Lignin		
Ash	1.2	1.2
NFE		
GE (MJ/kg)		12.5

1 Anon. 2005; 2 http://www.weightlossforgood.co.uk/nutrition/cabbage6.htm.

Minerals: Anon (2005) reported the Ca and P content of swamp cabbage were 0.11% and 0.04% (fresh matter).

The mineral content of cabbage

	Cabbage1 (ppm)
Cu	0.25
Mg	120
Fe	4.9
Ca	480
Se (μ/100g)	1
Zn	2
K	8530
Na	2770
P	430

1http://www.weightlossforgood.co.uk/nutrition/cabbage6.htm.

Amino acids: NA

Anti-nutritional factor: NA

AME and digestibility: NA

DE and digestibility: NA

Inclusion in diets: NA

Common name: Banana

Scientific name: Musa cavendishii

Description: Bananas are rich a source of carbohydrate, in the form of starch. Whole unpeeled, ripe bananas contain 20% DM and 1.0% CP (Calles et al., 1970). Green bananas contain 20 to 22% of DM, mainly starch. The high level of free active tannins in fresh green bananas and their residual presence in fresh ripe bananas is reflected in their negative protein digestibility. When bananas ripen, the starch changes into simple sugars, sucrose, glucose and fructose. Bananas can be fed to pigs either fresh, ensiled or in the form of a dry meal, even though the latter is extremely difficult to achieve. Ripe bananas are very palatable and their degree of ripeness affects performance. If non-peeled ripe bananas are fed ad libitum, the pig will first eat the pulp leaving part of the peel; however, fed on a restricted basis, both the pulp and peel are eaten. If fed high levels of green bananas, palatability will affect voluntary intake and a lower consumption will affect the performance. Bananas can be sliced when green, dried in the sun, and in this way consumption will improve.

Proximate composition:

The chemical composition of bananas

Items	DM	CP	CF	EE	Ash	NFE
Banana leaf meala (% DM)	94.1	9.9	24.0	11.8	8.8	45.5
Fresh banana leavesb (% DM)	19.5	11.4	28.3	-	10.9	-
Green bananasa (% DM)	20.9	4.8	3.3	1.9	4.8	85.2
Ripe bananasa (% DM)	31.0	5.4	2.2	0.9	3.3	88.2
Banana leavesc (% fresh)	17	0.8	0.6	0.6	0.9	
Banana fruitc (% fresh)	31	1.7	0.7	0.3	1.0	
Cooking banana fruitc (% fresh)	29.4	2.6	13.9	0.8	5.0	

a FAO 1993; b Garcia et al., 1991a; c Anon. 2005;

Minerals: The Ca and P content were 0.24 and 0.03% for fresh banana leaves, 0.23 and 0.09% for fresh banana fruit, 0.22 and 0.09% for cooking banana fruit on fresh matter basis (Anon. 2005).

Amino acids: The fresh and cooking banana fruit contents 0.02, 0.03 % lys, 0.02, 0.02 % Meth+Cys and 0.02, 0.02% Thr of fresh matter respectively (Anon. 2005).

Anti-nutritional factor: Fresh green bananas contain a high level of free active tannins and ripe bananas contain the residual of tannins from green bananas. Banana peels are very rich in active tannins when green and thus can not be fed until they are completely yellow, when the tannins are bound in an inactive form (Gohl, 1981).

AME and digestibility: NA

DE and digestibility:

The digestibility of different forms of ripe and green bananas for pigs

Type of banana	DM	OM	N	GE	DE (MJ/kg DM)	Source
Green banana	76.9	-	-102.0*	-	13.39	Clavijo and Maner 1973 (cited by Perez, 1997).
Ripe banana	84.3	-	-42.7	-	13.05	
Ripe banana meal	50.5	-	-126.6	-	7.13	
Green banana meal	83.6	-	3.4	-	13.42	
Green banana	83.5	84.2	-19.0	79.5	13.31	Le Dividich and Canope 1975.
Cooked green banana	87.9	88.6	26.4	84.3	14.39	
Peeled green banana	88.6	89.1	-1.6	85.5	14.39	
Ripe banana	89.5	90.1	38.4	85.5	13.92	

**Negative Protein Digestibility refers to the affect of this dietary component on total digestibility due mostly to the presence of lignin and tannins in green bananas*

The nutrient digestibility (%) of bananas (Gohl, 1981)

	CP	CF	EE	NFE	ME (MJ/kg DM)
Green banana, raw	46.9	46.6	55.9	94.7	12.7
Green banana, cooked	43.8	49.5	56.6	94.9	12.8
Ripe banana, raw	53.6	58.7	66.9	94.6	12.4
Ripe banana, cooked	51.8	62.6	69.2	95.4	12.5

Inclusion in diets:

- Pigs: Calles et al. (1970) studied the performance of growing/finishing pigs fed free-choice ripe bananas with a restricted amount of either a 30 or 40% protein supplement. Growth performance was improved (660 vs 700 g) when 30% supplement was used.

The performance of pigs fed different levels of green banana meal (30-90 kg)

% of DM in diet	ADG (g)	DM feed conversion	Source
0	670	3.66	Celleri et al., 1971.
25	650	3.88	
50	630	4.04	
0	620	4.09	Zamora et al., 1985.
20	620	4.12	
40	580	4.40	

Banana leaf meal: Banana leaf meal can replace up to 15% of total dietary dry matter for growing pigs

Banana leaf meal inclusion for pigs (14-28 kg)

% of DM in diet	ADG (g)	DM feed conversion	Source
0	506	2.63	Garcia et al., 1991b.
5	496	3.00	
10	505	2.91	
15	483	2.99	

Waste banana meal: 30% waste banana meal can be safely consumed by pigs.

- Poultry: Banana meal has been used in poultry diets, but high levels depress growth and reduce feed efficiency. Not more than 5% or 10% of the grain portion of chick and poultry diets was replaced by banana meal (Gohl, 1981).

Common name: Sorghum

Scientific name: Sorghum bicolour (L) Moench

Description: Sorghums can be classified into two types according to the level of tannin in the grain. Those with high tannin content are usually known as forage sorghum (ALFID, 2002). The seeds are low in fibre and high in energy. Dark brown or purple seeds contain high tannin, and will affect the digestibility of other nutrients. White seeds contain little tannin and are an ideal feed. It is essential that the type of sorghum is known to determine the true nutritional value (Ewing, 1997). Jacob, et al. (1996) reported that sorghum with high tannin content could be substituted for white maize in broilers starter diets with no significant adverse effects on growth or feed efficiency. The dietary treatments of increased CP or methionine levels were not required.

Proximate composition:

The chemical composition of sorghum (% DM)

Item	Serena sorghuma	White sorghuma	Sorghumc	Sorghumc	Sorghumc
DM	90.4	88.1	87.5	87.1	87.3
CP	10.73	11.46	11.2	10.8	12.3
EE	3.54	4.09			
CF	3.98	4.31	2.5	2.7	2.3
Ash	1.99	2.16	2.9	1.7	1.8

Tanninb	2.54	-	-	-	-
Crude fat	-	-	3.9	3.7	4.3
Sol.carbohydrate	-	-	69.5	73.9	73.2
Starch	-	-	-	73.2	72.8
NDF	-	-	-	9.0	6.6
ADF	-	-	-	7.1	6.3
GE (MJ/kg DM)	-	-	18.45	18.37	19.09
Lysine (g 16g N)	-	-	2.5	2.4	-

a Jacob et al., 1996. b Tannin content as catechin equivalents. -: not available. c Lekule et al., 1990.

The nutrient content (% DM) of sorghum

Item	Sorghuma
CP	13.40
Lignin	1.30
Monosaccharides	
Glucose	67.90
Soluble	56.35
Fibre	11.55
Other monosaccharidesb	4.24
Resistant starch	11.84
Crude fat	2.33
Tanninsc	0.08

a Morales et al., 2002. b Other monosaccharides contain galactose, arabinose, xylose, mannose, rhamnose and fucose. c Quercitannic acid (%).

Minerals: The mineral content of sorghum (air-dry basis): Ca 0.04%, P 0.31%, available P 0.09%, Na 0.05%, K 0.40%, Mg 0.14%, Mn 17.4 ppm, Zn 30.2 ppm, Fe 50.0 ppm, Cu 7.9%, S 0.09%, Cl 0.09% (Evans, 1985).

Amino acids:

The amino acid contents of sorghum cultivars (% air dry basis)*

Cultivar	Asp	Thr	Ser	Glu	Gly	Ala	Cys	Val	Met	Ile	Leu	Tyr	Phe	Lys	His	Arg
IS10246	0.73	0.34	0.48	2.16	0.33	0.91	0.22	0.49	0.23	0.37	1.29	0.22	0.54	0.22	0.23	0.36
IS2217	0.89	0.35	0.64	3.33	0.31	1.36	0.21	0.63	0.21	0.49	1.93	0.26	0.77	0.24	0.28	0.38
IS10644	0.85	0.39	0.56	2.64	0.35	1.15	0.24	0.60	0.22	0.45	1.67	0.27	0.69	0.25	0.25	0.38
IS10484	0.74	0.35	0.49	2.14	0.34	0.95	0.19	0.52	0.15	0.41	1.39	0.28	0.56	0.22	0.21	0.34
IS6451	0.82	0.36	0.54	2.49	0.33	1.07	0.23	0.54	0.15	0.45	1.58	0.29	0.63	0.24	0.25	0.38
IS8583	0.71	0.34	0.48	2.16	0.32	0.95	0.21	0.51	0.22	0.39	1.41	0.34	0.54	0.21	0.21	0.36
IS9180	0.72	0.33	0.48	2.11	0.33	0.94	0.19	0.49	0.24	0.39	1.36	0.18	0.56	0.23	0.22	0.31
IS16046	0.81	0.35	0.51	2.46	0.32	1.06	0.19	0.53	0.18	0.43	1.59	0.25	0.51	0.25	0.23	0.39
IS2670	0.71	0.29	0.47	2.40	0.27	0.98	0.16	0.47	0.17	0.37	1.39	0.20	0.55	0.21	0.21	0.32
IS16327	0.82	0.36	0.48	2.14	0.36	0.93	0.23	0.50	0.20	0.40	1.35	0.25	0.51	0.28	0.24	0.46
IS15526	0.66	0.30	0.40	1.90	0.27	0.87	0.16	0.41	0.12	0.36	1.26	0.11	0.46	0.18	0.19	0.26
IS15106	0.58	0.26	0.35	1.71	0.25	0.74	0.18	0.38	0.12	0.32	1.13	0.14	0.41	0.16	0.19	0.25
IS15070	0.86	0.37	0.54	2.56	0.32	1.11	0.22	0.60	0.20	0.45	1.62	0.25	0.48	0.25	0.24	0.37
IS4904	0.85	0.38	0.56	2.67	0.33	1.17	0.24	0.71	0.17	0.46	1.67	0.35	0.51	0.24	0.25	0.42
IS8671	0.72	0.32	0.45	2.04	0.32	0.89	0.20	0.49	0.15	0.38	1.29	0.21	0.51	0.22	0.23	0.34
IS9282	0.77	0.33	0.52	2.48	0.31	1.03	0.18	0.51	0.17	0.41	1.47	0.20	0.61	0.23	0.22	0.36

IS8070	0.66	0.28	0.43	2.04	0.29	0.83	0.15	0.43	0.19	0.35	1.19	0.18	0.52	0.20	0.20	0.33
IS15346	0.70	0.32	0.45	2.11	0.30	0.90	0.21	0.45	0.16	0.39	1.38	0.26	0.51	0.21	0.22	0.35
IS15612	0.72	0.30	0.43	1.83	0.30	0.80	0.18	0.45	0.14	0.34	1.15	0.13	0.38	0.21	0.20	0.33
IS1291	0.86	0.39	0.59	2.84	0.36	1.22	0.24	0.62	0.25	0.48	1.81	0.34	0.66	0.21	0.29	0.39

**Elkin et al., 1996.*

Anti-nutritional factor: Tannins

AME and digestibility: The true metabilizable energy of Serena sorghum (with high tannin contents) and white sorghum was 3869 and 4104 (kcal/kg) respectively (Jacob, et al., 1996).

The apparent ideal digestibility coefficients of protein and amino acids in sorghum for broilers*

Item	Sorghum1	Sorghum2	Sorghum3	Sorghum4	Sorghum5	Sorghum6
CP	-	0.83	0.79	-	0.82	0.74
Ala	0.84	0.88	0.89	0.83	0.86	0.79
Arg	0.80	0.83	0.86	0.78	0.81	0.75
Asp	0.77	0.82	0.82	0.78	0.82	0.72
Glu	0.84	0.88	0.90	0.84	0.87	0.80
Gly	0.70	0.73	0.75	0.66	0.74	0.64
His	0.73	0.76	0.80	0.74	0.72	0.66
Ile	0.83	0.83	0.84	0.78	0.84	0.74
Leu	0.84	0.87	0.89	0.83	0.85	0.79
Lys	0.75	0.72	0.75	0.75	0.79	0.70
Met	0.85	0.85	0.87	0.80	0.86	0.78
Phe	0.83	0.84	0.85	0.80	0.83	0.75
Ser	0.73	0.79	0.80	0.74	0.76	0.70
Thr	0.66	0.70	0.72	0.64	0.68	0.58
Tyr	0.79	0.81	0.80	0.73	0.79	0.67
Val	0.80	0.81	0.83	0.76	0.81	0.71

**Ravindran et al., 1998.*

DE and digestibility:

Digestibility of nutrients (%) and content of metabolizable energy for pigs

Sorghum	Sorghuma	Sorghuma	Sorghuma
DM	88	87	89
OM	90	89	91
CP	71	69	76
Crude Fat	50	51	53
CF	64	67	70
NFE	96	95	96
Energy	87	86	88
Metabolizable energy (MJ/kg DM)	15.72	15.49	16.35

a Lekule et al., 1990.

Inclusion in diets: Limits are directly related to tannin content. Low tannin content sorghum can be fed as sole grain component to all pigs (ALFID, 2002).

Common name: Sweet potato and sweet potato vines

Scientific name: Ipomoea batatas Lam.

Description: Sweet potato with a high yielding capacity has a high content of carbohydrate (80-90% of DM), and is highly digestible and soluble (Fashina-Bombata and Fanimo, 1994) and with a low content of crude protein, fat and fibre. Sweet potato tubers are highly digestible and excellent source of energy. Sweet potatoes can also be used fresh or dehydrated in rations for livestock (Gohl, 1981). Sweet potato is also a source of important vitamins, such as vitamin A, ascorbic acid, thiamine, riboflavin and niacin. The fresh vines can provide up to 27% of the dry matter and 40% of the total dietary protein for growing/finishing pigs (Perez, 1997). Dustiness and fungal growth during sun-drying are problems, but these can be overcome by boiling the tubers, which is actually the form in which they are fed by smallholders. The peels are also available for scavenging (E. B. Sonaiya). The uncooked starch is very resistant to hydrolysis by the enzyme amylase, when cooked, the hydrolizable starch fraction increases from 4 to 55% (Cerning-Beroard and Le Dividich, 1976). Sweet potatoes can be chopped, sun-dried and used as an energy source for pigs. Sweet potatoes can be fed raw, cooked and as a silage for pigs as well (Wu, 1980).

Proximate composition:

The chemical composition (% DM) and gross energy (MJ/kg DM) of sweet potato products or as indicated

Item	Sweet potato1	Sweet potato root2	Sweet potato vines3	Sweet potato chips (sun-cured) 4	Fresh sweet potato root 5	Sweet potato vines (Fresh)6	Sweet potato vines (Hay)6	Sweet potato vines 7	Sweet potato vines 8	Sweet potato leaves (fresh) 9	Sweet potato leaves (dried) 9
DM	88.7	-	12.3	90.8	39.4	18.1	86.0			18.0	95.0
OM	-	-	85.2	-				86.7	82.2	98.6	98.6
CP	4.3	4.4	13.5	5.0	2.1	17.2	17.0	21.2	19.1	26.8	26.9
Ash	2.8	3.1	14.8	3.4	1.3	8.4	10.5	12.4	17.8		
CF	-	-	-	3.2	0.1					12.8	12.8
NDF	5.5	6.9	50.6	9.7				42.1	49.8	28.5	25.4
ADF	3.6	4.2	33.9	7.8		40.5	32.5	27.5	36.4	18.2	17.1
ADL	0.9	-	0.5	1.0							
Lignin	1.7	0.7	-	-				7.7	5.4		
EE	-	0.6	-	0.8	0.2			10.4	2.2	0.7	0.7
Starch	75.9	-	-	80.4							
Sugars	-	-	-	-							
NFE	-	-	-	87.6							
GE	-	17.1	-	-							

1 Dewhurst et al., 1995. 2 Noblet et al., 1990. 3 Kariuki et al., 1998. 4 Manfredini et al., 1993; 5 Anon. 2005; 6 Brown and Chavalimu, 1985; 7 Dung et al. 2002; 8 Farrell et al. 2000; 9 Van An et al. 2004.

Minerals: Sweet potato chips (sun-cured) contain 0.20% of Ca and 0.14 (% DM) P (Manfredini et al., 1993). Sweet potato vines contain 0.50% of Ca and 0.28 (% DM) P (Kariuki et al., 1998). Anon. (2005) reported that the Ca and Zn content of fresh sweet potato root were 0.08 and 0.08% respectively.

The mineral content of sweet potato

	Sweet potato feed1 (%)	Sweet potato vines (mg/kg DM)2	Sweet potato leaves (mg/100g fresh)3
Salt	0.4		
Ca	0.2	10.5	33.4
Total P	0.2	2.4	
Avail. P	0.1		
Mg	0.1	3.7	32.3
K	0.75	5.8	242.2
Na	0.25	2.8	12.1
S		3.4	
Cl	0.25		
Cu	-	15	
Fe	-	2029	0.8
Mn	-	308	
Zn	-	39	3.1

1 Ewing, 1997; 2 Farrell et al., 2000; 3 Mosha and Gaga, 1999.

Amino acids: The amino acid content of sweet potato products

Amino acid	Sweet potato roots1 (% protein)	Sweet potato vines2 (% protein)	Sweet potato vines3 (% protein)	Sweet potato vines4 (%DM)	Sweet potato leaves (fresh) 5 (g/16g N)	Sweet potato leaves (dried) 5 (g/16g N)
Isoleucine	4.2-10.1	3.9-5.1	4.9	0.57	3.73	4.18
Leucine	7.8-9.2	6.2-7.9	9.6	1.08	8.58	8.83
Total sulphur	2.8-3.8	3.0-3.9	2.8			
Phenylalanine + tyrosine	11.9-13.6	6.2-10.1	10.6			
Threonine	5.5-6.3	5.1-6.1	5.3	0.56	5.22	5.23
Try	0.8-1.2	-	-			
Valine	6.8-8.3	4.9-8.2	6.3	0.72	5.60	5.74
Lysine	4.2-7.2	4.3-4.9	6.2	0.62	4.48	4.14
Alanine				0.78	5.22	5.39
Arginine				0.74	5.22	5.20
Aspartic acid				1.87	10.45	11.02
Cystine				0.21	3.36	3.20
Glutamic acid				1.57	11.57	9.87
Glycine				0.72	4.10	3.52
Hisdine				0.26	2.24	1.99
Methionine				0.26	1.49	1.56
Phenylalanine				0.69	7.09	6.88
Proline				0.55	3.73	3.40
Serine				0.56	4.10	4.06
Tyrosine					4.10	3.95

1 Purcell et al., 1972. 2 Li, 1982. 3 Walter et al., 1978; 4 Farrell et al., 2000; 5 Van An et al. 2004.

Anti-nutritional factor: Usually no major anti-nutritional factors. Moulds can grow if stored for long periods or if moisture level is high (Ewing, 1997).

AME and digestibility: The AME of fresh sweet potato root was 4.52 MJ/kg (Anon. 2005), 14.8 MJ/kg for sweet potato feed (DM) (Ewing, 1997) and 12.5 MJ/kg DM for sweet potato tuber (Gohl, 1981).

DE and digestibility: DE content of sweet potato was 14.64 (MJ/kg DM) (INRA, 1984). Wu (1980) reported that DE of sun-cured, ground sweet potato chips for young pigs (6.5 kg) was 14.63 (MJ/kg). DE of fresh sweet potato root was 5.22 MJ/kg (Anon. 2005).

The digestibility coefficients (%) and DE (MJ/kg DM) of sweet potato for pigs

Ingredient	DM	OM	N	CP	CF	NDF	ADF	EE	NFE	GE	DE
Sweet potatoa	-	91.0	-	52.1	37.5	58.2	40.3	53.2	96.0	89.3	15.25
Sweet potatob (Raw)	90.4	92.1	27.6	-	-	-	-	-	-	89.3	14.1
Sweet potatob (cooked)	93.5	94.5	52.8	-	-	-	-	-	-	93.0	14.5
Sweet potatoc (Raw)	95.3	96.1	49.8	-	-	-	-	-	-	94.2	15.8
Sweet potatod (cooked)	85.5	-	76.0	-	-	-	-	-	-	89.2	14.7

a Noblet et al., 1993. b Canope et al., 1977 (cited by Perez, 1997). c Rose and White, 1980. d Dominguez, 1992.

Inclusion in diets:

- Pigs: Fresh sweet potatoes can replace 30-50% of the grain in pig diets. Cooking increases the value of sweet potatoes (Gohl, 1981). The inclusion level of sweet potato meal for grower pigs (25-60kg) was 33% in soyabean based diet (Fashina-Bombata and Fanimo, 1994). ME of fresh sweet potato leaves and dry leaves were 9.5 MJ/kg DM (Van An et al., 2004).
- Poultry: Sweet potato root meal can be included up to 50% in poultry feeds with good results if properly supplemented with protein. Sweet potato vine meal can be added at about a 3% level to broiler and layer feeds to heighten the pigmentation of eggs and meat (Gohl, 1981). Dried sweet potatoes have been fed successfully in rations for broilers and layers at a level of up to 35%. Teguia et al. (1997) studied the effect of replacing 200 or 300g of maize/kg in the broiler finisher diet with sweet potato leaves found that the replacement of maize at these levels significantly depressed body weight gain.

Food intake, live weight gain and food conversion ratio of chickens grown to 21 days of age and the apparent metabolisable energy (AME) of five diets (MJ/kg DM) with different levels of sweet potato vine (SPV) meal replacing lucerne meal (Farrell et al., 2000)

Diet (g/kg)	Food intake (g)	Weight gain (g) at 21 days	Food conversion ratio	AME
0 SPV	867	601	1.447	13.81
40 SPV	883	610	1.449	14.20
80 SPV	870	614	1.444	14.67
120 SPV	857	584	1.469	13.89
160 SPV	831	579	1.461	13.75
SEM	26.6	21.6	0.021	0.086

Common name: Chilli

Scientific name: Capsicum Annuum L.

Description: Chillies are important spice for human beings. Inclusion of spices in diets usually not consider as nutrient supplement, but enhancing taste, increasing intake, promoting digestion and adding medical values (Pradeep et al., 1991; 1993). This is probably because spices stimulate digestive secretions and enzymes such as saliva, mucin, salivary amylase, bile juice (Desai et al., 1977; Limlomwongse et al., 1979). Reddy and Lokesh (1992) reported that capsaicin (25-150um) from red chillies protects the unsaturated lipids against peroxidation. Protecting polyunsaturared fatty acids from peroxidation is essential to utilize their beneficial effects in health and in preventing disease. Capsaicin can be used for treatment of cutaneous allergy and neurological disorders such as diabetic neuropathy (Palevitch and Craker, 1995). It inhibits bacterial growth, platelet aggregation (Cichewicz and Thorpe, 1996) and the oxidation of serum lipoproteins by reducing the rate and susceptibility to oxidation (Ahuja and Ball, 2006). Pradeep et al. (1991) used rats to study effect of spices on utilization of sorghum and chickpea protein found that red chilli + coriander (1:1) mix increased the utilization of absorbed protein of sorghum rather than just absorption, but had no effect on chickpea protein. Proximate and energy content (per 100g DM edible parts) of red chillies were 95.76g DM, 5.26g ash, 16.69g protein, 22.81g fat, 42.9g crude fibre and 609 kcal energy (Pradeep et al., 1993).

Proximate composition:

Chemical composition of chillies (Saimbhi et al., 1977)

Variety	**DM%**		**CP% (fresh)**		**Ascorbic acid (mg/100g fresh)**	
	Green	Red	Green	Red	Green	Red
Black Hungarian-I	13.89	21.48	1.70	3.00	150.6	256.2
Black Hungarian-II	13.04	15.69	2.65	3.12	134.0	244.7
Rajpura Long-6	13.51	20.48	1.67	2.82	114.0	158.4
All season-2.1	13.84	21.88	2.03	4.66	111.0	178.4
All season-1.2	13.49	25.47	1.44	3.72	108.7	159.8
N.P.-46-A	18.46	18.44	1.96	3.73	192.4	225.6
Long red-4.2	15.82	23.78	2.01	3.69	134.5	206.8
Long red-4.3	15.47	26.96	1.96	5.85	134.6	193.6
Rajpura-2	13.30	24.80	2.06	3.30	152.5	261.1
Nawanshehar chilli	13.42	21.66	1.70	5.50	96.3	131.1
Abohar-12-3.2	16.51	30.18	2.01	4.30	131.5	172.1
Selection-8	13.04	20.11	2.13	3.29	164.8	293.7

Minerals: Pradeep et al. (1993) reported that mineral contents of red chilli (per 100g DM edible parts) were 58.4 mg Ca, 258.6mg P, 9.58mg Fe, 1.82mg Mn, 162.8mg Mg and 1.82mg Zn.

Mineral content (mg/100g fresh chilli) of chillies (Saimbhi et al., 1977)

Variety	**P**		**Zn**		**Cu**	
	Green	Red	Green	Red	Green	Red
Black Hungarian-I	51.96	75.18	0.34	0.55	0.18	0.25
Black Hungarian-II	46.29	75.31	0.24	0.37	0.15	0.22
Rajpura Long-6	54.04	81.92	0.41	0.43	0.24	0.30
All season-2.1	55.36	89.59	0.33	0.48	0.17	0.19
All season-1.2	51.93	87.27	0.26	0.40	0.14	0.18

N.P.-46-A	66.98	82.05	0.46	0.47	0.17	0.32
Long red-4.2	58.53	95.12	0.38	0.61	0.18	0.27
Long red-4.3	54.14	102.44	0.44	0.69	0.12	0.26
Rajpura-2	50.54	93.00	0.28	0.49	0.16	0.24
Nawanshehar chilli	50.32	77.39	0.28	0.49	0.16	0.21
Abohar-12-3.2	63.56	128.26	0.33	0.63	0.14	0.37
Selection-8	53.52	82.45	0.29	0.41	0.23	0.27

The ascorbic acid and the mineral contents in different chilli varieties (Khadi et al., 1987)

	Ascorbic acid (mg/100g)		**Mineral content in dry red fruits (mg/100g)**								
Varieties	Ripe fruits	Green fruits	Zn	Cu	Mn	Fe	Na	K	Ca	Mg	P
Byadgi	247.82	116.55	0.53	0.20	0.08	0.98	11.00	2460	60.00	28.00	35.00
SPR III-7-6	151.43	97.26	0.64	0.54	0.20	1.20	21.00	3220	80.00	20.00	30.00
Puri red	28.74	18.88	0.35	0.48	0.28	1.10	20.33	2500	38.00	25.33	25.00
EC-76459-2	299.89	254.60	0.56	0.63	0.16	1.08	12.97	3480	59.97	18.00	30.27
IC-14045	291.93	96.05	0.42	0.48	0.17	1.14	29.00	4040	56.00	11.67	19.00
387 local	204.57	59.72	0.62	0.41	0.16	1.14	21.10	5180	48.77	18.73	25.63
Lathigolar	289.33	71.01	0.34	0.56	0.16	0.83	29.73	2950	49.63	28.80	26.93
Jwala	274.78	161.20	0.48	1.30	0.23	1.02	31.87	2850	49.67	19.87	50.00
NP-31	265.55	175.33	0.38	0.43	0.22	0.80	15.60	2600	45.30	24.30	19.50
IC-18190	208.08	68.20	0.30	0.50	0.20	0.91	9.70	3030	54.30	19.80	20.00
Sankeshwar	207.26	92.63	0.20	0.34	0.05	0.98	11.13	2830	49.67	28.57	22.10

Amino Acids: Amino acid contents of red chilli (g/100gN) (Pradeep et al., 1993)

Amino acid	**Red chillies**
Isoleucine	1.99
Leucine	3.31
Threonine	2.44
Tryptophan	0.84
Valine	2.86
Lysine	4.38
Alanine	3.82
Arginine	16.11
Aspartic acid	9.87
Cystine	1.28
Glutamic acid	7.95
Glycine	4.94
Hisdine	2.73
Methionine	0.66
Phenylalanine	1.92
Proline	5.02
Serine	3.22
Tyrosine	1.25

Anti-nutritional factor: Red chilli contains 0.80% of Tannins, 0.16% (DM) phytic acid and 0.672 trypsin inhibitors units (Pradeep et al., 1993).

Common name: Clover

Scientific name: Trifolium Spp.

Description: Clover contains relatively high crude protein, minerals and soluble carbohydrate (Ayres and Poppi, 1993). Leaf protein concentrates from red clover is good source of carotene. Feeding chickens with this concentrates increased storage of carotenoid in the chicken liver (Szymczyk et al., 1996). The nutrient composition of clover changes with maturation. For example, protein content was 28.6% and lignin content was 5.9% at Day 130 of the subterranean clover, but it was 16.5% for protein and 9.0% of lignin at Day 200 after sowing (Weston and Hogan, 1971). Leaves contain more protein than stems. Nordkvist et al. (1987) reported that red clover leaves contained 27.4% DM protein and stems contain 11.0% DM protein.

Proximate composition

The proximate contents of clover

	Red clover1	Subterranean clover (cv. Junee; mature)2	Persian clover (cv. Kyambro; mature)	White clover3	Red clover4	Red clover5	White clover5
	%DM	%DM	%DM	%	%	%DM	%DM
DM	12.7					21.2	20.5
OM		86.9	87.9				
CP	16.8	16.5	17.2	20.6	16.6	22.8	21.9
Ash	12.0	13.1	12.1			8.5	
NDF	49.2	52.1	50.5	36.4	39.6	49.3	37.0
ADF	34.8	40.8	39.1	24.8	28.7		12.6

1 Gosselink et al. (2004); 2 Li et al. (1992); 3 Ayres and Poppi, 1993; 4 Mir et al. (1995); 5Djouvinov et al. (1998).

Mineral contents of clover products

	Subterranean clover (cv. Junee; mature)1	Persian clover (cv. Kyambro; mature)1	Red clover leaves2	Red clover stems2
	g/kg DM	g/kg DM	%DM	%DM
Ca	14.1	15.5	2.75	0.85
P	2.2	2.2	0.26	0.17
Na	1.1	1.4	0.019	0.013
K	27.6	19.6	1.52	2.69
S	1.6	2.1		
Mg	2.3	2.6	0.38	0.29
	mg/kg DM	mg/kg DM		
Fe	674.3	643.6		
Mn	114.8	122.7		
Zn	27.9	35.7		
Cu	12.4	10.3		

1 Li et al. (1992); 2Nordkvist et al. (1987).

Amino acids: Amino acid contents of red clover juice

Amino acid	Red clover juice (mg/100ml)1
DM (%)	8.2
Isoleucine	41
Leucine	95
Threonine	66

Valine	68
Lysine	88
Alanine	102
Arginine	66
Aspartic acid	150
Cystine	9
Glutamic acid	147
Glycine	71
Hisdine	42
Methionine	13
Phenylalanine	72
Proline	74
Serine	66
Tyrosine	56

1Juice was extracted in a laboratory screw press and clover at the full-blooming stage (Hanczakowski and Szymczyk, 1992).

Anti-nutritional factor: It contains tannins, cyanogenic glycosides and saponins (Essig, 1985).

AME and digestibility: Digestible energy for cattle was 11.0 MJ/kg (Essig, 1985).

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11.2 Appendix 2: Survey of smallholder village poultry farming in the Solomon Islands

11.2.1 Summary

This survey was carried out as part of the ACIAR collaborative project 'Feeding Village Poultry in the Solomon Islands (ACIAR REF: LPS/2003/054). The survey was intended to provide a baseline to monitor changes and impacts of the projects extension activities and also as a learning exercise to better understand the situation of small scale village poultry farmers and their needs and how this and future project/s could best support them

90 farmers in 31 villages of Guadalcanal, Western Province, Malaita and Central provinces were interviewed in this survey aimed at collecting baseline information on the current feeding practices and farmer attitudes to village poultry production. Most surveyed farmers thought chickens were easy to care for a good enterprise to get cash income and extra food for the family. Some farmers are interested in keeping local chicken, but there is shortage. Some respondents stopped keeping chickens due to predators or stealing or they sold or ate all their chickens. The main feed sources are fresh coconut, food scraps, insects such as white ants, copra meal, fish meal, mill run and free-range. The problems respondents faced is a lack of available information and training on local chicken management. Most people concentrate on working in the garden or keeping pig or RCDF. Many people tried keeping poultry, but lack knowledge on how to manage chicken farms.

Some respondents know how to build a chicken house by using bush materials or bought materials like nails and wires (materials collected by themselves). Others need help. Farmers would like government officers to provide fence materials such as wire netting to keep predators away such as dogs. Some think chicken eat rubbish and mess around. Some people feed chicken with sweet potato beet but not provide water. Chickens often get water from stand pipe when they are out of the house. Children feed and care for chicks. Some respondents use septrin tablets to make chicken recover from diarrhea. Some people learn how to care for chickens from grandparents help.

11.2.2 Materials and Methods

The survey team was drawn from Kastom Gaden Association and MAL/SICHE research facility scientist. The survey team members were Thecla Vapusi, Hilda Karani and Joseph Wahananiu. Tony Jansen assisted and helped train the KGA survey enumerators at the first survey site on the weather coast. The survey questionnaire was developed through a series of meetings between MAL and KGA where the ACIAR baseline survey used in a Papua New Guinea project was used as the template and adapted to the needs and context of the Solomon Islands project. Questionnaires were also designed to collect information about ownership, size of village poultry operations, reasons for keeping broilers, aspects of management and disease, marketing and social problems, attitudes to broiler keeping, main problems faced, types of assistance farmers need and their future intentions regarding broiler production.

The survey form was tested in the field at Avuavu during the first survey field trip and some changes and adaptations were made. The survey enumerators learned to gather. The same team of enumerators carried out the survey in the three selected sites accompanied by local language speakers from the farm schools:

- Kolombangara
- Malaita
- Guadalcanal

These three sites were chosen as they are in the area of farmer schools that are intended to establish models and extend the results of the project to the community. Some training activities by the KGA have already been underway in these areas for some years and so

the results may not represent the 'average' rural area but none the less as a baseline it was considered these communities were the ones who would most likely benefit from the research project and so changes could be monitored. The survey covered the villages of Veranoli, Namoku, Haemarao, Moku, Botuvua, Lualua, Bubuvua, Haimarao, Pubuvua, Vera chiria, Boliu, Salakulikuli, Haemaro and Vatuli in Guadalcanal province; Sauboro, Sausama, Tanahuka, Nusamaheri, Tanhuka, Nusamahiri, Tanuhuka, Damidami and Nusamari in Western Province and Fuliauladoa, Gwunafiu, Busurata, Lalita, Bialau and Kwalo in Malaita province.

Note: Limitations – low responses for some questions, confusion between scoring terms – eg sometimes and occasionally.

Table 1. Questionnaire used in village meat chicken farmer survey

No.	Survey of Feeding Village Poultry
2(a)	Age
	50 and over
	25 to 35 years
	35 to 50 years
	18 to 25 years
	Under 18 years
4	Main source of income
	If other answered please describe here
	Betel nut
	Craft
	Employed
	Copra and cocoa
	Other income supply of food fro training session
4(a)	Main source of food
	Any other comments
	Bush food
	Pork
	Market and friends
6	Have you kept a village chicken at any time in the last 12 months?
7	Are you aware of neighbouring farmers who keep village chicken?
8	Why are you not keeping village chicken?
	Predators
	Stealing
	No access to feed and birds
	Finance and market
	Disease
8(a)	Explain
	No house and no fence
	Birds, theft, no house
	No body is willing to give her any chicken for free
	Need to built a house for chickens
9	Are you thinking about starting to keep village chickens?
10	What do you need to get started to keep village chickens
	How to make feed
	Better access to markets

	Better access to feed, chicks and markets
	Credit
	Other
	Explain
	Fencing and housing
	Stealing and predator
	Have you ever kept chickens in the past?
	If yes why did you stop?
	Theft
	Management
	Predators
	Chicken
11	How many birds do you have now?
11(d)	How many chickens did you sell this year?
11(g)	Has the number been increasing or decreasing since Christmas?
	Decreasing
	Increasing
	How many chickens did you share with others since Christmas?
11(k)	Do you know if village chickens are in demand?
	Yes
	No
	Not many people demand village chickens
	Village school
11(l)	What product do people buy?
	Meat
	Eggs
	Neither
11(p)	Who are the main buyers?
	Villagers
	School
	Waku from companies
	Company, Vanga RTC.
	Home consumption
	Relatives around the village
	Do not know
11(q)	What is the cost of village chicken?
	None
	No available
	Do not know
11(r)	What is the cost of layer eggs
	None
	No available
	Do not know
	Purpose
12	Why are you keeping village chicken?
	Home consumption
	Social status
	Cash income

	Other
	Roosters for fighting
	Bride price
12(a)	When did you start keeping chicken?
	Last year
	Over 10 years
	2-4 years
	5-10 years ago
	Never
12(b)	Did anyone help you get started?
12(c)	If yes, Who
	MAL or NGO
	Family
	Friends
	Neighbour
	Other
13	Housing
13(a)	Where do the chickens roost
	Chicken house
	Trees
	Home
	Other
	On the ground
13(b)	Do the chickens have a house?
	Chicken house
	Trees
	Other
	In the kitchen
	Under house
13(c)	If yes, describe the house:
	House (built with local materials including leaf house)
	Moveable houses
	Just start
13(d)	Roof material
	Copper
	Leaf
	Other
	Bamboo
	Cut timber
	Bush sticks
	Palm trunk
13(e)	Walling material
	Bush sticks
	Wire
	Bamboo
	Other
13(f)	Floor

	Earth
	Timber
	Cement
	Bamboo
	Other
13(g)	Litter
	Leaves
	Grass
	Sawdust
	Sand
	Paper
	Other litter
13(h)	Number of rooms
13(I)	If more than one room how do you separate chickens in the different rooms?
	Roosters, hens, chicks
13(j)	How often do you replace the litter
	1-2 days
	1-2 weeks
	1-2 months
	Never
	After six months
13(k)	What do you do with the used litter?
	Use it on garden
	Give away
	Sell it
	Other
13(l)	Where does the hen lay eggs?
	In the chicken house
	In the family house
	in the kitchen
	In bush
	Other
13(m)	When the chicks hatch what do you do to care for them?
	Observe carefully
	Confine
	Nothing
	Give extra food
	Other
13(n)	If they have a brooding system:
	Use of paper cartons
	For how long are chickens confined in brooder?
	one week or less
	2 weeks
	3 weeks
	4 weeks
	Over 4 weeks
	Do you cover the brooder at night?
	Sometimes

	Is heating supplied?
	Source of heat
	Kerosene
	Electricity
	Generator
	Economic
	Cost of raw materials to build house
	Cost of equipment, feeders, drinkers, buckets, pipes
	Cost of litter
	Did you have to pay for these materials or collect for free?
	Collect and free
	Pay
	Other
14	Water
	Where do the chickens get water?
	Water is given in container
	Find it on their own
	Other
	If water is given:
	Source of water
	Water supply
	River
	Rain water tank
	Pool
	Other
	Type of containers
	Plastic dish
	Bamboo
	Shell coconut
	Drinker
	Clamshell
15	Feeding
15(a)	What do you feed your chickens?
	Food scraps
	Coconut - fresh
	White ants
	Chickens are free ranging
	Copra meal
	Fish meal
	Mill run
	Other
15(b)	Please describe in detail if other feeds are used:
	Left over food and other
	Coconut grating
	Coconut plus fruit and vegetables
	White ants, cooked Kumara
	White ants
	Paw paw and other

	Cabbage (cassava leaf)
	Cooked kumara
	Cooked kumara, rice, cassava
	Coconut, kumara, worms
15(c)	What do you notice the chickens like to eat that they find on their own
	Grass and insects
	Insect
	Worm, left over food /compost
	Rice, insects and chilli
	White ants, coconut
15(d)	If you buy feed in town how do you transport the feed?
	By own family or labour
	Do not transport feed
	By public transport
	By water
	Other
15(e)	How much do you pay for this transport?
15(f)	How often do you feed?
	Once a day
	Twice a day
	Feed every few days
	Feed occasionally
	Feed is always there
15(g)	Comments:
15(h)	Do you do any preparation of feed?
	Cooking
	Scraping / cutting
	Mixing of feeds
	Drying
	Other
15(I)	Other (describe)
	Mixing of feed
	Drying
	Collecting ant
	Cooking
	Feed chickens with dried scraps coconut under sunlight
	Collect left over kaikai for chicken
15(j)	Do you store the feed
	Other
15(k)	If you store feed are there losses of stored feed?
	Rats
	Birds
	Mould
	Insects
	Other
	How many eggs does the hen sit on?
16	Diseases or Deaths

	How many chicks usually hatch from one hen?
16 (a)	How many birds usually die per brood of chicks from one hen?
	All
16(b)	How do you know if birds are sick?
	Appearance
	Not eating
	Diarrhoea
	Don't know
16(c)	Do you notice any different kinds of sickness?
	Eye closed
	Scabs on comb and legs (fowl pox)
	Others
	Lice under feathers
	Scaly legs
16(d)	What do you do if a bird is sick?
	Kill it
	Eat it
	Nothing
	Use own traditional medicine
	Ask a relative or friend for help
	Ask for help from an extension officer
	Sell it
17	Who does the work in looking after chicken
	Feeding
	Male
	Female
	Chief
	Other
	Parents
	Husband and wife
	Relative
	Hired help
	Watering
	Hired help
	Cleaning of rooms
	Care of sick birds
	Buying of feed and chicks
	Selling
	Transport
	Hired help
	Payment of hired help (how much or choose from list)
	Give labour exchange
	Pay for labour
	In kind - give chickens
	Give garden produce
	Other
18	Selling
	Who makes decisions about selling birds?

	Man
	Woman
	Father and mother
	Relatives
	All family
	Who decides on the price?
	Man
	Mother/father
	Relatives
	All family
	Depends on size
	Market
	How is this decision made?
	Size of production
	Current market price
	Competition with other producers
	Comparison with supermarket frozen chicken
	As much as buyers are willing to pay
	Other
	What is time for selling based on?
	Weight of birds
	Market demand
	Price
	Need for cash
	Number of weeks
	Other
	Where is marketing done (Name of place)?
	At home or in the village
	Local market
	Provincial centre
	Honiara market
	Other
	Who buys?
	Villages
	Schools and colleges
	Teachers, students , nurses
	Amone
	Waku, noro campanies
	PSS/CBTC
	Relatives
	Are there transport costs to get birds to market?
	Yes
	No
	Other
	How much is transport?
	Do you travel to market only to sell chickens or also for other purposes?
	Sell garden produce
	Other things

	The P.S.S come and buy at home
	What do you do with the income earned?
	Family essentials
	Saved
19	Social Problems
	Do you suffer from any of the following causes of problems?
	Demands for gits
	Jealousy
	Theft
	Disease
	Predators
20	Help Needed
	What kind of help do you need or would you like?
	Information:
	Feeding managements
	Housing and fencing
	More information in practical
	Types of feeds, disease & treatment
	Disease recognition & treatment
	Training:
	Housing
	Feeding and management
	No idea
	Practical on fence ,feeding
	Housing, fencing
	Why chicken should in the village?
	Care and management, feeding, fence material
	How or from who do you get information?
	MAL
	NGO (Specify)
	Kastom garden & gwunafiu farmer school
	RTC
	Friends and Neighbours
	Other women
	Other men
	Don’t know
	Other youths
	Radio
	Other (specify)
	Yes
	No
	NGO
	Unless someone comes, agriculture man useless. just stay quite long in house
	If you do not get any information or help why is this (your opinion)
	No interest
	No outside help
	Lazy

	Not many people feeding chicken
	Continues with the project
	Would you welcome visits from an extension agent?
	If yes, how often?
	Once a month
	3-6 months
	Weekly
	Once a year
	They should propose program for women
	At any time they want to visit us.
	Not sure
21	Future Plans
	What is your future intention with respect to village chicken?
	Expand
	Undecided
	Stay the same
	Stop keeping chicken
	If they chose to expand what is the target size of operation?
	Give any reasons for your decision
	Sales increase
	Income
	Not willing
	Kaikai / Sell
	No proper housing
	Income & food
	Income for breeding
	Because of stealing problem
	If relative ask ,chicken can be a gift
	Will decide later because they have plenty to do
	They want the money for helping themselves for buying needs for family
22	Attitudes
	What do you think is good about keeping village chicken?
	Easy to manage
	Increase income
	Good for meat
	What do you think is no good about keeping village chicken?
	Predators
	Create mess
	Round the village, don’t want to keep chickens when grass is weak
	Damage crops
	Poor management
	Need more food for them, no management for chickens, they can spoil your plant or flower
	Take longer to reach market size , high care of the younger once, no proper care
	No housing and birds are main problem because no management
	Going into people house if not kept in confinement
23	Any other comments

11.2.3 Data collection and analysis

During the interviews, farmers who had not kept village chickens in the last 12 months and those who were only planning or preparing to go into chicken production were required to respond only to certain questions, whereas those who kept village chickens in the last 12 months and/or are currently keeping village chickens had to respond to a greater number questions to provide more detailed information on their broiler operation. For each of the questions a number of different answers were provided. These answers were given a score and were analysed firstly to determine if there were distinct variation and then if there was any overall differences in the answers given. The differences between the provinces were assessed with ANOVA in Systat software (Wilkinson, 1996). Bonferroni's post hoc was used to separate means only if significant main effects were detected by analysis of variance. Bonferroni's post hoc test is a multiple comparison test based on Student's t statistics and adjusts the observed significance level when multiple comparisons are made. The responses were compiled and analysed using SYSTAT. Responses by farmers on the various aspects of broiler production are compared between 3 provinces. Survey questions were listed in table 1.

11.2.4 Results

Sex and Age: In 84 surveyed farmers, 55.9% were male and 44% were female. There was no significant (P>0.05) difference in gender from this survey. The ages of surveyed farmers were from under 18 to over 50 with more farmers (38.2%) aged between 25 to 35 years old and less farmers (12.4%) aged between 35 to 50 years old (Figure 1).

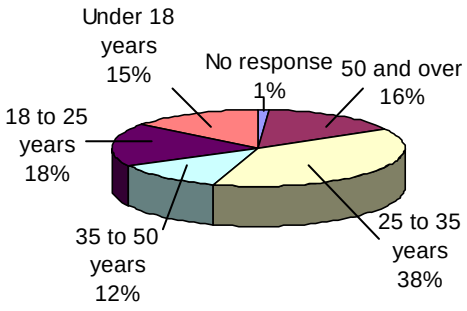


Figure 1. Age group surveyed

Main sources of household income

Primary sources: By far the most important source of income for the majority of households is the sale of fresh garden produce (57.7%). This is followed by sale of cooked food (23.6%) which generally involves use of garden and other fresh produce (Table 2).

No more than 10% of households had any other important source of household income. Paid employment was at 10%, copra and cocoa 6.6%, others 5.5% (including betel nut and crafts which were not included in the survey list), fishing 4.4%. Pigs and chicken meat were important income sources for only 3.3%bof households. Chicken eggs were even lower at 2.2% of households.

Table 2. The main sources of income.

Source of Income	Important1	Sometimes2	Never
Garden	57.7	33.3	8.9
Chicken Meat	3.3	41.1	48.9

Chicken eggs	2.2	21.1	68.9
Pigs	3.3	36.7	57.9
Copra / Cocoa	6.6	31.1	57.8
Fishing	4.4	32.2	58.9
Other3	5.5	40	41.1
Paid income	10.3	18.3	55.2
Selling cooked food	23.6	11.8	23.5

1 Includes 'important' and 'very important responses combined together
2 includes 'Sometimes' and 'occasional' responses included together
3 Other sources included betelnut, crafts, employment, supply food for training centers.

Secondary sources: Secondary sources of income (occasional and sometimes) were more spread out and showed the diversity of other income sources as a complement to garden produce. Here the importance of livestock stands out. Chicken meat is a secondary source of income for 41% of households followed by pigs (36.7%), gardens (33.3%), Copra and cocoa (31.1%), fishing (32.2%) chicken eggs (21.1%) paid income (18%) and cooked food (11.8%). Others accounted for 40% including betel nut and indicates other sources of income not included in the list are also important.

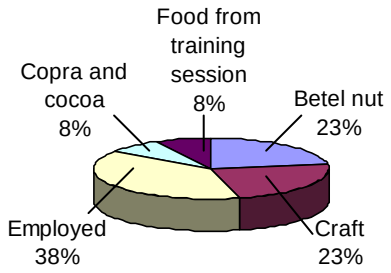


Figure 2. Other sources of income.

Never a source: The majority of households never receive income from chicken eggs (68.9%), fishing (58.9%), copra, cocoa and pigs all 57.8%, paid income 55%. A small minority (8.9%) had never received income from gardens, cooked food (23.3) and other (41%). Chicken meat was in the middle with 48.9% never getting income from it.

Looking at poultry production based incomes we can see that of the 33.3% of households who earn income from eggs, 2.2% found it an important source of income, 21% an occasional source of income and presumably the remainder a very minor.

Main sources of Household Food

The garden is the most important source of food for 94.4%of households followed by fishing (10%), store (6.7%), others (5.6%), chicken eggs (4.4%),chicken meat (4.3 %), market (3.3%) and pigs (2.2%) (Table 3).

Table 3. The main sources of food.

Source of food	Important	Sometimes/Occasional	Never
garden	94.4	2.3	2.2
Chicken meat	4.3	43.4	47.8
Chicken eggs	4.4	43.4	47.8
Pigs	2.2	54.5	38.9
Market	3.3	68.9	23.3
Fishing	10	72.2	12.2

Store	6.7	40.9	22.7
Other1	5.6	40.9	22.7

1 Others included Bush foods, wild pigs, and friends.

Again in secondary sources of food livestock is more prominent. Store food scores the highest (87.8%) followed by fishing (72.2%), market (68.9%), Pigs (54.5%) chicken eggs and chicken meat (43.4%) and others (40%).

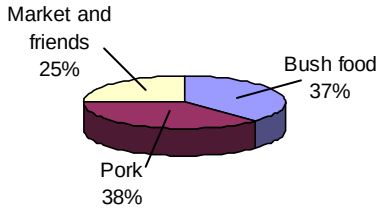


Figure 3. Other sources of food.

Keeping village chickens: 82.1% of surveyed farmers were aware of neighbouring farmers who kept chickens. In the last 12 months, 62.4% surveyed farmers kept village chickens, which was significantly more ($p<0.01$) than the farmers who did not keep chickens. The reasons for not keeping village chickens were predators (10.8%), stealing (8.1%), no access to feed and birds (27%), finance and market (16.2%), disease (2.7%), do not know how (21.6%) and other (13.5%) such as no house, no fence, no free chickens available (Figure 4).

The most frequent problem of 'no access to feed and birds' at (27%) appears to relate to problems with breeding /multiplication of poultry, start up stock and also a desire for high input 'broiler' or 'layer' chickens with commercial feed as this has been the prevalent model of poultry improvement to date. Unfortunately this question was not broken into its two component parts meaning that this response unintentionally mixes together those who are not able to feed and breed local bird along with those who desire imported birds and imported feed and or better local feed and those who desire both. Future surveys should turn this into two categories as quantifying the demand for feed versus demand for birds is important to the project. The second most important reason for not keeping poultry was 'lack of skill '(21.6%). Had the first category been broken down into access to feed and access to birds, the lack of skill response would probably have been the highest scoring.

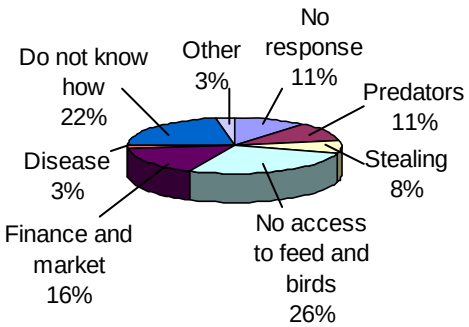


Figure 4. The reasons for not keeping village chickens.

The other category included: the need for appropriate housing as well as 'people not willing to give chickens for free' as start up stock, which is perhaps a similar response to 'no access to feeds and birds but cannot be differentiated form the 'other group'. 11% did

not provide a response perhaps indicating they did not have any obstacle to getting started and or survey error.

82.9% of surveyed farmers would like to start keeping village chickens, 8.6% of the farmers would not and 8.6% of the farmers had no response. This high level of response could reflect three possibilities: 1) A high desire to keep poultry but faced with constraints that prevent them from starting; 2) The intermittent nature of raising poultry in the village – ie they raise them some times, then stop for periods, and then raise them again; 3) Inflated response due to survey effect – ie telling the interviewer what they wanted to hear.

The second possibility is further supported by the response that 67.7% of the non-poultry farmers have kept chickens in the past, only 29% had never keep chickens in the past, 3.2% had no response. The reasons for not keeping chickens were; predator problems (52.9%), poor management (35.3%) and theft (11.8%).

Needs to start keeping chicken farms: The needs for starting a farm are better access to feed, chicks and markets to start keeping chickens (36.4%), better access to feed, chicks and markets, credit, fencing, housing and controlling stealing and predators (27.3%). The others needed information on how to make feed (9.1%), better access to markets (6.1%), credit (3%) and other (5%) such as fencing and housing, controlling stealing and predators and a combination of the above needs (6.1%) (Figure 5).

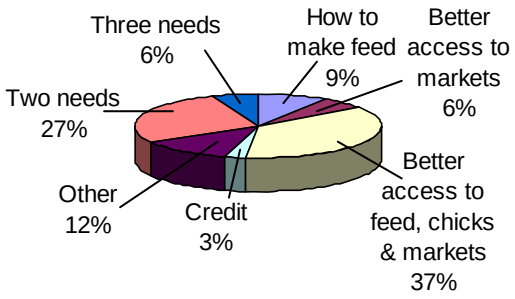


Figure 5. The needs for starting a chicken farm.

Number of birds kept: 98% of the farmers did not keep records and so production numbers were very difficult to ascertain reliably. Current numbers of chickens kept by the respondents were from 1-53, hens kept from 0-30, roosters were from 0-10 and chicks 0-41. The numbers of chickens were increasing for 59.6% of households, decreasing for 31.6% of households (Figure 6). The number of chickens sold in the year of the survey was 0-20. The range of chickens sold was 0-50 and 0-12 were share with others since Christmas.

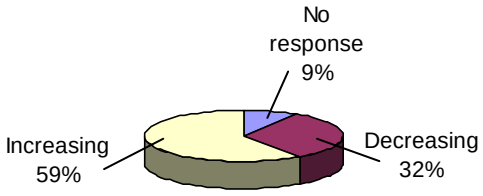


Figure 6. The numbers of chickens kept by surveyed farmers since Christmas.

Market: 80.8% of households believe there is strong demand for village chickens in the local market and within the village. 7.7% of the respondents did not think so; 3.8% of the respondents thought not many people had a demand for village chickens; 3.8% of the respondents thought village schools demand chickens and 3.8% had no response (Figure 7). People who bought the chickens did mainly for meat consumption (94%), fewer people bought eggs (2%), or bought both meat and eggs (2%). 2% of surveyed farmers thought consumers did not buy any meat or eggs. The price for local rooster ranged from 20 to 50 (SI$), 10-40 (SI$) for a local hen, 1-10 (SI$) for local chicks.

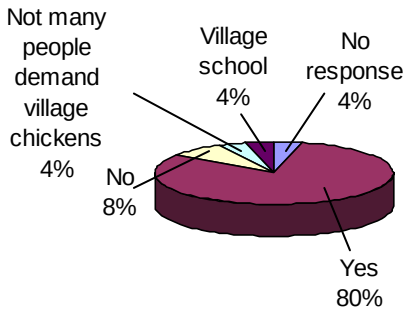


Figure 7. Farmers thoughts of marketing of village chickens.

Other villagers are the main market (60.5%), but sales to schools (18.4%), local companies, Vanga RTC and rural training centres are also important. Only 2.6% was for home consumption. 5.3% of surveyed farmers do not know who the village chicken buyers were (Figure 8). The respondents did not know how much it cost for a local village chickens and eggs (42.9%). Others indicated it did not cost any thing for both chickens and eggs (42.9%). No response for this question was 14.3% of respondents.

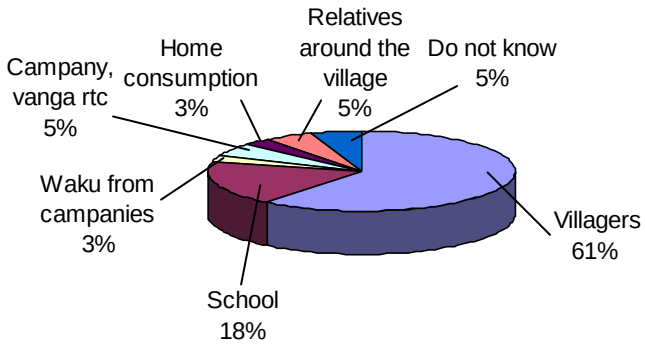


Figure 8. The main chicken consumers.

Purposes for keeping village chickens: The purpose for keeping broilers were mainly a combination of home consumption, social status, cash income and roosters for fighting (83.8%) (Figure 9). Keeping village chickens for home consumption was only 3.2%, 6.5% for social status, 4.8% for cash income and 1.6% for roosters for fighting.

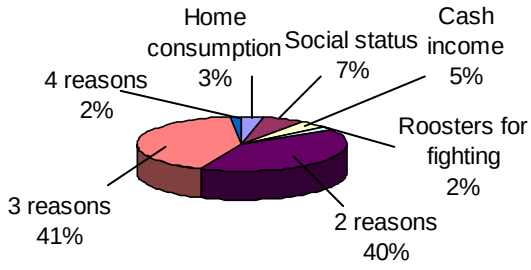


Figure 9. The reasons for keeping village chickens.

38.7% of surveyed farmers began to keep chicken last year, 35.5% of respondents kept chicken for 2-4 years and 12.9% of respondents kept for 5-10 years or over 10 years respectively (Figure 10). This provides further evidence that poultry raising is an intermittent household livelihood strategy with most households not persisting beyond 4 years and then perhaps restarting again after a period of time. Respondents were asked if they received any help to get started with raising poultry. A majority (52.7% received no help) with 47.3% receiving help. The main source of assistance is family members (66.7%). Extension workers from MAL and NGOs were 12.1% and were the second most important source of help but well below family support. Friends and neighbors were 6.1% each indicating that most assistance follow family relationship lines as opposed to other unrelated villagers. Among the helpers, 69.6% were male and 30.4% female ($p<0.01$).

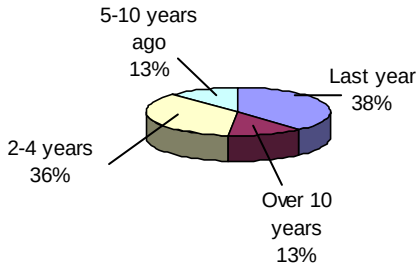


Figure 10. The years farmers have been keeping village chickens.

Housing: Existence of houses for chickens was high at 66.7%, which indicates that only 1/3 of these houses are in regular use by birds roosting inside. Chickens also found in trees (12.5%), in the kitchen (4.2%), under the house (4.2%) and other places (12.5%). When ask where the chickens roost, 38.3% of surveyed farmers said chickens roosted in the trees, 20% of chickens roosted in chicken house. A combination of two of these places (chicken house, trees, home and on the ground) made up 25%. Other places chickens roosted included home (10%), on the ground (1.7%) and other places (5%) (Figure 11). This indicates inconsistent management or changing habits of poultry.

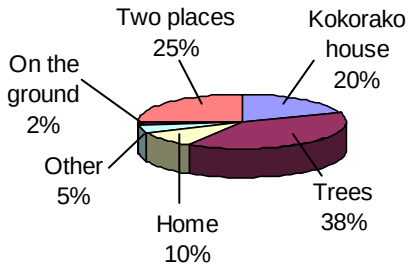


Figure 11. The places chickens roost.

Building of houses is generally at no cash cost to the household. Most chicken houses (88.2%) were built by local materials including leaf house; some houses were moveable (5.9%) and 5.9% of surveyed farmers had not built a chicken house as they were just starting (Figure 12). Most roof materials (59.1%) were leaf, other materials included copper (13.6%), bamboo (4.5%), cut timber (4.5%), bush sticks (4.5%), palm trunk (4.5%) and other materials (9.1%). Leaf is considered the superior material because it keeps the poultry cool. However on the weather coast and in bush Malaita leaf rots faster and is less readily available than in many other areas of Solomon Islands and this may partly account for increased desire to use iron roofing despite it is much higher cost. Most common materials for wall was other materials (42.9% no specification), 35.7% of wall material was bamboo, 14.3% of wall material were bush sticks and 7.1% of wall material was wire. 50% of floor material was earth, 20% was timber, 5% was cement, 5% was bamboo and 20% was other material (no specification).

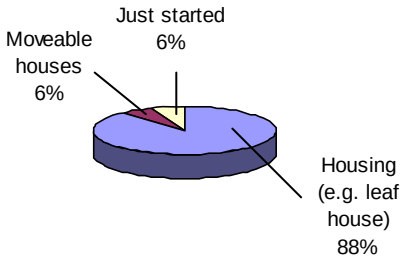


Figure 12. Housing materials.

Majority of households with chicken house are using some kind of dry organic matter for litter. Most litter materials were grass (41.2%), other materials included leaves (11.8%), sawdust (11.8%), sand (5.9%), paper (5.9%) and other (23.5%). Other response may refer to houses who do not put any litter in the poultry house. When asked how often farmers replace the litter, 50% of the surveyed farmers said never, 20.8% said 1-2 months, 12.5% said 1-2 weeks, 8.3% said 1-2 days and 8.3% said after 6 months (Figure 13). When asked what do you do with the litter, 56.5% of surveyed farmers did not respond, 17.4% said it was used in garden, 17.4% gave it away, 4.3% sold it and 4.3% said other options (no specification). A majority gave no response and presumably do not use litter and simply throw it away or burn it. Most houses have only one room (66.7%) showing the continuing influence of the broiler model where large numbers of chickens of uniform age are raised in one room. The kGA model, which promotes more than one room (ideally at least 3) was also evident in being taken up by some farmers. 22% had 3 rooms and 11% had two rooms.

Among two or three rooms, 40% of surveyed farmers did not separate rooms into different rooms, 20% of them separated rooms into rooster, hen and chick house; 20% of them were separated into open room, and 20% of them were not applicable. When ask where does the hen lay eggs, 7.3% of surveyed farmers did not respond, 21.8% said in the family house, 12.7% said in the chicken house, 12.7% said in the kitchen, 10.9% said in the bush. A combination of two or three these places (the chicken house, the family house, the kitchen, the bush) made up 30.9%. Other places (no specification) made up 3.6%. This means hens have inconsistence laying habits – sometimes laying eggs in the house and sometimes in other places etc.

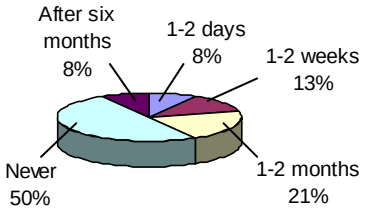


Figure 13. The frequency of replacing litter.

A brooding system: Care of chickens is split between those who 'do nothing' (30.8%) and those who 'observe carefully' (30.8%). 17.3% said they were confined and protect the chicks, while 15.4% gave extra food. Other practices amounted to 1.9% and a further 1.9% had a combination of the above (Figure 14). 85.7% of surveyed farmers did not have brooding system, 14.3% of surveyed farmers used paper cartons for brooding. The length of brooding was 20% each for one week or less, 2, 3, 4 and over 4 weeks. When asked do you cover the brooder at night, 38.5% of surveyed farmers did not responded, 32.1% said yes, 30.8% said no and 7.7% said sometimes. Only 16.7% of surveyed farmers provided heating for brooders, 16.7% said sometimes and 66.7% of surveyed farmers (6) did not respond. The main source of heat was kerosene (50%), the other heat sources were electricity (25%) and generator (25%).

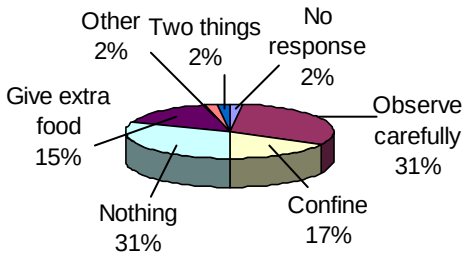


Figure 14. Things farmers do when the chicks hatch.

Cost of raw materials to build house: Most raw materials (78.9%) were collected by themselves with no cost, 5.3% of surveyed farmers did not respond, 10.5% said they paid the cost of materials, 5.3% said other (no specification) (Figure 15). There was no answer for the question about how much it cost for feeders, drinkers, buckets, pipes and litter materials.

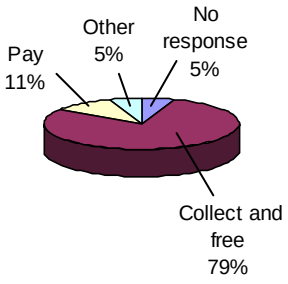


Figure 15. Cost of raw materials to build a chicken house.

Watering: When ask where do the chickens get water, 64% said chickens found water on their own, 32% said water is given in containers (Figure 16). The common container was bamboo (45%), plastic dish (25%). The other containers included shell coconut (20%),

drinker (5% commercial drinkers) and clamshell (5%). When asked about the source of water, 5.6% of surveyed farmers did not respond. However, the main water source was water supply (55.6%), other sources included river (8.3%), rain water tank (11.1%), pool (11.1%) and other (8.3% no specification).

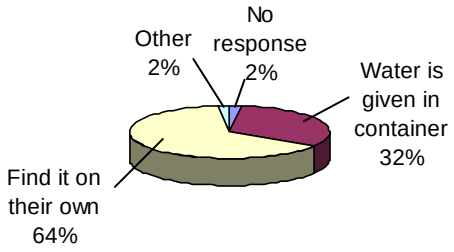


Figure 16. The methods chickens obtained water.

Feeding: The main feed for chickens is fresh coconut (54.2%, either with the milk squeezed out for cooking or as fresh wet coconut) and food scraps (32.2%). A much lesser number of households use a wide range of other locally sourced feeds with the most common being white ants (3.4%). Other local feeds mentioned include cooked kumara, pawpaw, cassava leaf, cabbage and greens, rice, cassava, worms, kumara (uncooked). Less than 2% of households (1.7% each) used purchased feed ingredients – fish meal and mill run. A slightly larger number used purchased copra meal (3.4%) which may be more locally available (Figure 17 and 18). Chickens had also been noticed eating grass and insects (56.3%), insects (35.4%), worms, left over food/compost (2.1%), rice, insects and chilly (2.1%), white ants and coconut (4.2%) (Figure 19). Overall different types of grasses and insects are considered the preferred foods of poultry. This is a very generic response and perhaps reflects those who less observant about what the chickens eat than those who gave more detailed responses. Further interviewing on this topic could help to add detail of specific insects and grasses that might be used in feeding trials.

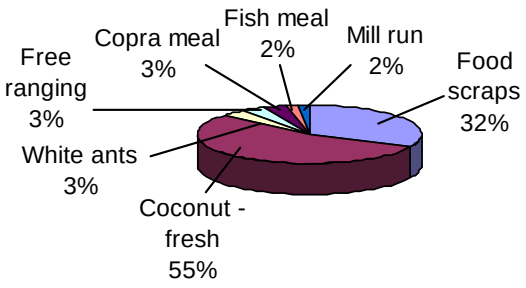


Figure 17. The main sources of feed.

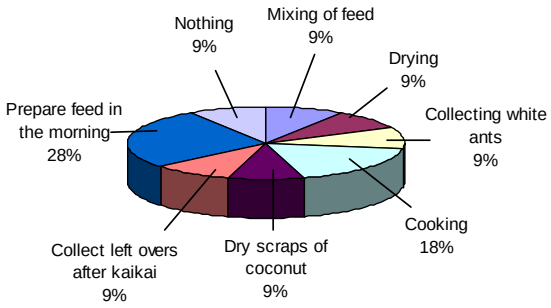


Figure 18. Other sources of feed.

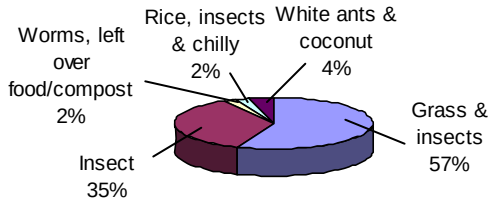


Figure 19. What farmers noticed chickens grazed on.

Approximately one fifth (18%) of respondents are in the ‘low care’ or ‘no care’ group with feeding less than once a day – ie every few days or only occasionally. These poultry can be assumed to be in a semi wild system. 18.5% feed once a day and 61% feed twice a day. As the most common feed is coconut this feeding probably coincides with family meal preparation as coconut is used in almost all meals in Solomon Islands and dry coconut meal is a by product of family food preparation. This group probably represents a mix of low care and high care households – ie those who just throw away some food scraps and dry coconut left over from the kitchen versus those who actually prepare coconut, white ants and other foods for their poultry.

When asked if you buy feed in town how do you transport the feed, 38.7% of surveyed farmers did not respond, 32.3% of the farmers did not need to transport feed, only 16.1% of the farmers transported feed by own family or labour, only small percentage of farmers used public transport (3.2%), by river or sea (6.5%) and other (3.2% no specification) (Figure 20). No one answered the question on how much it cost for them to transport feed.

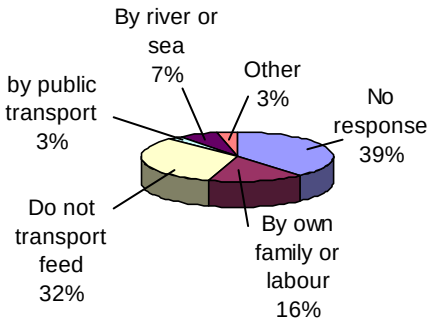


Figure 20. The ways farmers transport feed.

When asked do you do any preparation of feed, 26.7% of the respondents did not respond. 42.2% of the farmers scraped/cut feed before feeding chickens, 13.3% said they cooked food, 8.9% said they mixed the feed, 4.4% said they dried the feed and 4.4% of

surveyed farmers used other options including mixing feed (9.1%), drying (9.1%), collecting ants (9.1%), cooking (18.2%), sun drying scraped coconut (9.1%), collecting left over kaikai (9.1%), prepared in the morning (27.3%) and nothing (9.1%) (Figure 21). 72.3% of surveyed farmers did not store feed, 14.9% stored feed, 10.6% of respondents did not respond, 2.1% of respondents said other ways (no specification). When ask there were any losses of stored feed, 67.9% of respondents did not respond. There were feed losses through rats (14.3%), birds (3.6%), mould (3.6%), insects (3.6%) and other (7.1% no specification).

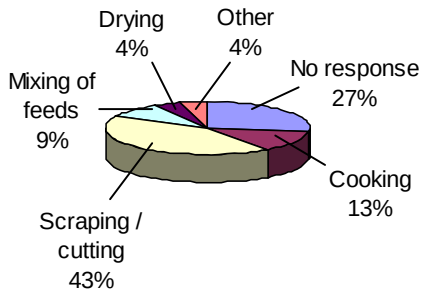


Figure 21. The ways farmers prepared feed.

Hatching: When asked how many eggs does the hen sit on, 12.2% of surveyed farmers did not respond, 30.6% said 10-12 eggs, 28.6% said 8-10 eggs, 18.4% said over 12 eggs, 8.2% said 5-8 eggs and 2% said 0-5 eggs. When ask how many chicks usually hatch from one hen, 31.3% of the respondents (48) said 10-12 chicks, 27.1% said 8-10 chicks, 14.6% said 5-8 chicks, 12.5% said over 12 chicks and 10.4% said 0-5 chicks (Figure 22).

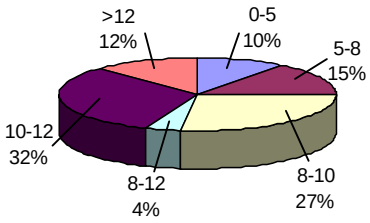


Figure 22. Numbers of chicks hatched from one hen.

Diseases or deaths: When ask how many chicks usually die per brood of chicks from one hen, 8.7% of the respondents did not respond. 17.4% said none, 34.8% said 1-2, 26.1% said 3-5, 8.7% said 6-9 and 4.3% said all dead. When asked how do you know if birds are sick, 28.9% of the respondents did not know bird was sick. For those who knew the bird was sick by its appearance (36.8%), not eating (26.3%), diarrhoea (5.3%), a combination of two of these reasons (appearance, not eating and diarrhoea) (2.6%) (Figure 23).

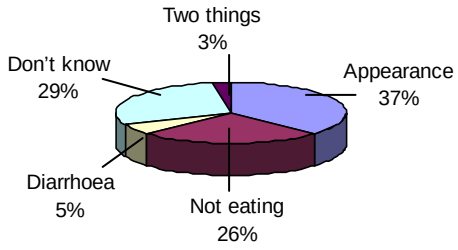


Figure 23. The ways farmers knew that chickens were sick.

When asked do you notice any different kinds of sickness, the answer yes and no was 75% vs 25% ($p<0.01$). 48.9% of the respondents noticed sometimes the bird eye was closed, 19.1% did not respond, 12.8% thought that the eye being closed was rare and 19.1% said very common. When ask do you notice scabs on comb and legs, 29% of the respondents said sometimes, 54.8% did not respond, 12.9% said rare and 3.2% said very common. When ask do you notice lice under feathers, 41% of the respondents said sometimes, 28.2% did not respond, 5.1% said rare and 25.6% said very common. When ask do you notice scaly legs, 32.3% of the respondents said sometimes, 54.8% did not respond, 9.7% said rare and 3.2% said very common. 28% of the respondents did nothing with the sick bird, 22% killed it, 22% ate it, 14% said they used own traditional medicine to treat the sick bird, 4% asked a relative or friend for help, 2% asked help from an extension officer, 2% sold it and 6% of the respondents did not respond (Figure 24).

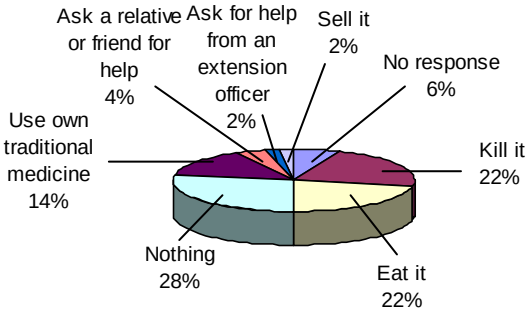


Figure 24. The ways farmers treat sick birds.

Workload: The task of feeding broilers was carried out usually by male (42.9%) or female (46.9%) members of the family and sometimes by relatives (6.1%) and hired help (2%) (Figure 25). 34.4% of the respondents did not respond on the question who provided water for birds. Female members of family did more on providing water than males (43.8 vs 15.6% $p<0.01$). Relatives (3.1%) and hired help (3.1%) helped to provide water as well. Female members of family did more cleaning of chicken sheds and watering birds than males (21.4% vs 7.1% $p<0.01$). Relatives (3.6%), parents (7.1%) and other (7.1%) helped to clean the chicken house as well. However, 53.6% of the respondents did not respond to this question. When asked who cared for the sick birds, 50% of the respondents did not respond. This high number of no responses indicating this task is often not done at all making poultry fairly gender neutral in ‘no care’ system of management.

Females (26.9%) of males (23.1%) did similar amount of work looking after the sick birds. When ask who buys feed and chicks, 87.5% of the respondents did not respond. 8.3% of the males bought feed and chicks and only 4.2% of the females did. When ask who sell the chicks, 37.1% of the respondents did not respond. 37.1% of females and 25.7% of males sold the chickens (Figure 26). When asked who transports poultry, 87.5% of the respondents did not respond. 4.2% of males, 4.2% females and 4.2% hired help transported birds. When asked how they payed the hired help, 69.6% of the respondents did not respond. The ways the hired help were paid included giving labour exchange (8.7%), paying for labour (4.3%), in kind-giving of chickens (4.3%), giving garden products (4.3%) and other (8.7%, no specification).

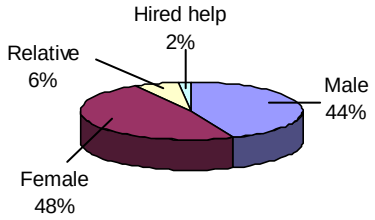


Figure 25. People who feed chickens.

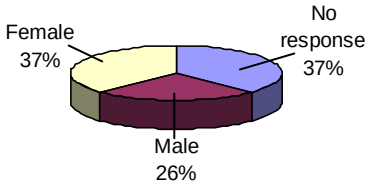


Figure 26. People who sell the birds.

Selling of birds: Selling of birds was done mainly by females (41.7%), but males (22.2%), parents (11.1%), husband and wife (13.9%), all family (2.8%) and relatives (5.6%) also did this work. People were making decisions on the price, included males (19.4%), females (25%), chief (2.8%), parents (16.7%), husband and wife (8.3%), relatives (2.8%) and all family (2.8%). The price also depended on size (2.8%) and market (16.7%). When asked how decision was made, 17.4% of the respondents did not respond. However, a few factors influence the decision, including size of product (30.4%), current market price (39.1%), competition with other producers (2.2%), comparison with supermarket frozen chicken (2.2%), as much as buyers are willing to pay (2.2%), family opinion (2.2%) and other (4.3%, no specification) (Figure 27).

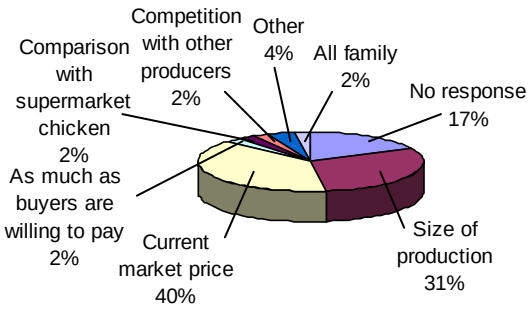


Figure 27. Factors influencing the price of chickens.

Time of sale: Time to sell birds was based on several factors, including weight of birds (24.4%), market demand (26.7%), price (4.4%), need for cash (4.4%), number of weeks (2.2%) and other (17.8%, no specification) (Figure 28). Village chickens were sold mainly at home or in the village (59.6%). The other places included local market (14.9%), provincial centre (4.3%), Honiara market (2.1%) and other (6.4%, no specification). The main consumers were villages (42.1%) and schools and colleges (36.8%) (Figure 29). The other consumers included teachers, students, and nurses (2.6%), amone (2.6%), waku, noro campanies (2.6%), PSS/CBTC (5.3%) and relatives (5.3%). When ask are there transport costs to get birds to the market, 24.1% of the respondents did not respond. 69%

of the respondents did not pay for transportation, only 3.4% of them payed for transport cost ($p<0.01$). Farmers normally went to market not just for selling chickens, but they also did other things (57.9%), sell garden products (36.8%). 5.3% of the farmers did not go to market to sell chickens because the P.S.S. came to the home to buy the chickens. The income from selling the chickens was mainly spent on buying family essentials and only small amount was saved (3.3%) ($p<0.01$).

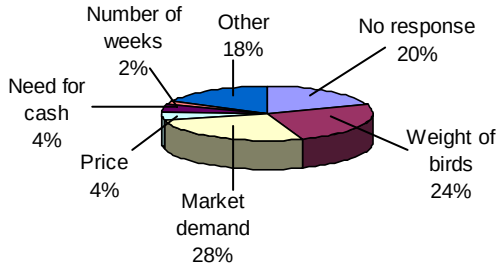


Figure 28. The time to sell chickens.

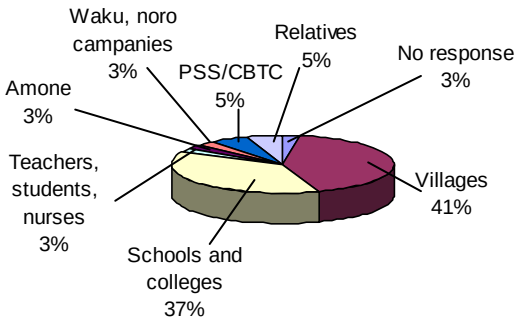


Figure 29. The main chicken consumers.

Social problems: Most farmers faced more or less some social problems (87.1 vs 12.9%, $p<0.01$) (Figure 30). These problems included demands for gifts (51.5 vs 48.5%, $p>0.05$), jealousy (18.5 vs 81.5%, $p<0.01$), theft (64.1 vs 35.9%, $p<0.01$), diseases (30 vs 70%, $p<0.01$) and predators (95.7 vs 4.3%, $p<0.01$). The predators were rats (2.1%), dogs (23.4%), snakes (2.1%), birds (10.6%) and a combination of two (29.8%), or three (17%) or four (10.6%) of these predators (rats, dogs, snakes, birds and cats).

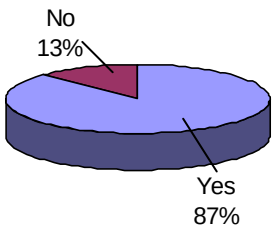


Figure 30. Surveyed farmers suffering from social problems.

Assistance needed: Farmers indicated they need assistance in a number of aspects of village poultry production. Most information was needed in feeding managements (75.7%) (Figure 31). Other information included housing and fencing (8.1%), more information on practical aspects (2.7%), feeding, types of diseases and treatments (5.4%), disease recognition and treatment (5.4%).

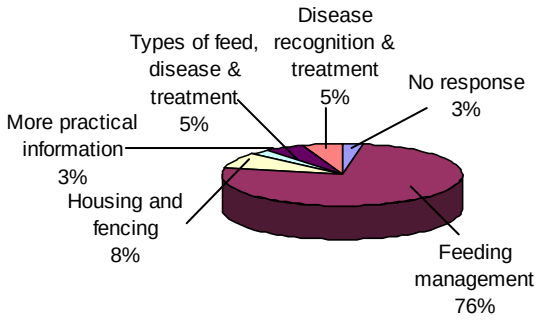


Figure 31. Information farmers needed.

The training farmers needed was feeding and management (50%), housing (31%), practical information on fencing and feeding (2.4%), housing and fencing (7.1%), about the type of chicken that should be in the village (2.4%), care and management, feeding, fence material (4.8%). 2.4% of surveyed farmers had no idea what kind of training they needed (Figure 32).

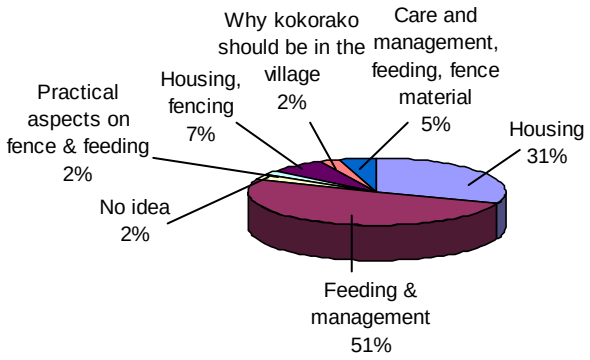


Figure 32. The training farmers needed.

Sources of information on chickens: NGO's are the main source of information on poultry among respondents. The NGO sources included:

- KGA 37.9%
- Turusuala Community based Training Centre 6.9%
- Sausama Farmer School 3.4%

Note that the latter two ar community based organizations in Guadalcanal and Malaita respectively who are part of the KGA network.

RTC's were mentioned by 24.1% which increases to 31% if Turusuala Community based Training Centre making RTC's a close second to KGA in supplying information to poultry farmers.

Friends and neghbours are sources of information for 21.7% of households followed by MAL extension officer at 19.2%. Some negative comments were recorded on some survey forms on agriculture extension officers such 'agriculture man useless – stay long haus no moa'.

As a majority of households do not access any help it was asked why. The reasons were:

- Not interested – 55.9%
- No one to ask or no one available 32.4%

However 96% of respondents said that they would welcome visits by an NGO or MAL extension officer. When asked how often they would like to be visited most said once a month (45.8%), every three to six months (31.3%). Only 8% thought weekly visits were necessary and 4.2% would be satisfied with a visit once a year (Figure 33).

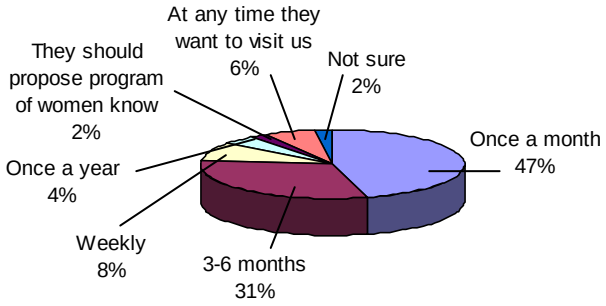


Figure 33. The frequency farmers would like an extension officer to visit.

Future plans: More farmers would like to expand the numbers of chickens (85.1%) compared to undecided (9%), stay the same (3%) and stop keeping chicken (1.5%) ($P<0.01$). The target size of operation ranged from 1 to 300 birds. The main factor for farmers making a decision was income and food (71.4%) (Figure 34). The other reasons included increasing sale (12.5%), kaikai/selling (1.8%), income for breeding (1.8%), gift for relative (1.8%) and money for family needs (1.8%). The reasons for not keeping birds included not willing to keeping birds (1.8%), no proper housing (1.8%), stealing problem (1.8%) and too busy (1.8%).

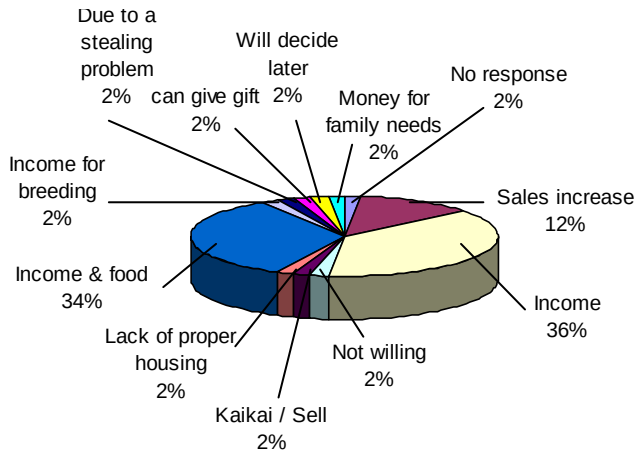


Figure 34. The reasons by farmers intend to keep village chickens in future.

Attitudes towards village poultry production: The majority of farmers interviewed thought keeping village chickens was good income (50%). They also thought village chickens were easy to manage (44.8%). Few farmers thought keeping village chickens was good for meat consumption (3.4%) (Figure 35). When ask what you think is no good about keeping village chicken, 42.6% of the surveyed farmers thought keeping village chickens would create mess (42.6%). The other problems included predators (10.6%), roaming around the village (2.1%), damage crops (14.9%), difficult to manage (14.9%), more food is needed for birds, management required and damage plants or flowers (2.1%), take too long to reach market size, more care is needed for young chicks and no proper care (2.1%), no housing (2.1%), going to people's house (2.1%) and create mess and difficult to manage (2.1%) (Figure 36).

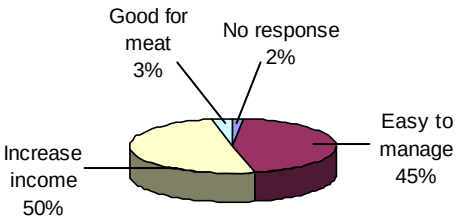


Figure 35. The positive aspects of keeping village poultry.

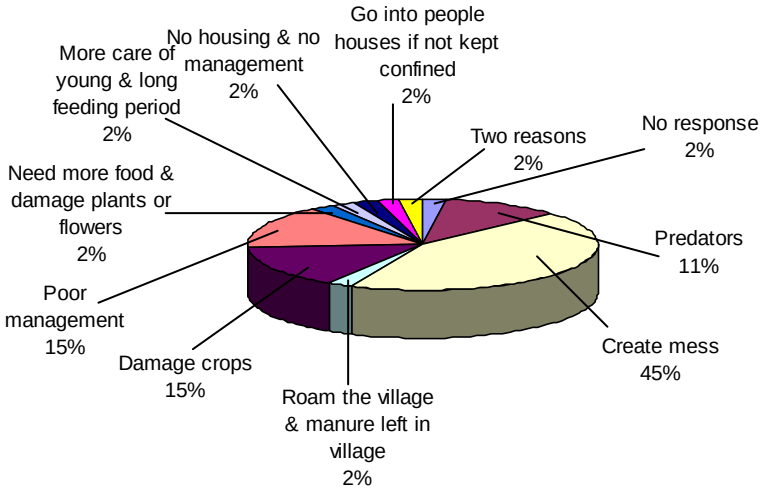


Figure 36. The negative aspects sides of keeping village chickens.

Comparison between provinces

Sex: Most surveyed farmers in Western Province and Malaita were males (62.5 and 73% respectively), while in Guadalcanal most surveyed farmers were females (66.7%) ($P<0.01$).

Income sources: The sources of income varied in provinces. In Guadalcanal income from chicken meat was significantly more important than in western or Malaita. For chicken eggs there was a significant difference between all 3provinces. Malaita had the highest percentage of households involved in selling eggs, while in western province there were none. For pigs again Guadalcanal placed more importance for income than western or Malaita.

An important finding is that 62-100% of households never sell poultry eggs. For Guadalcanal weather coast copra and cocoa are not very feasible due to geographic and transport constraints. However western province returned similar results to Guadalcanal indicating that the importance of copra and cocoa may be over rated. Guadalcanal had the highest reliance on paid income- most likely in the form of circular migration to Honiara although this was not asked in the survey (Figure 37).

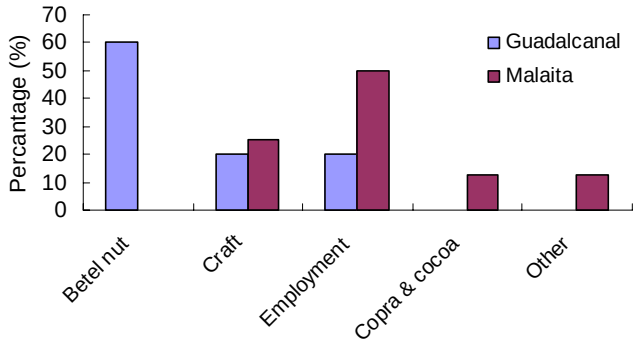


Figure 37. Other income sources in Guadalcanal and Malaita.

Food sources: Most of surveyed farmers in the three provinces thought garden products was an important food source (86.2% in Guadalcanal, 93.8% in Western Province and 97.3% in Malaita; P>0.05). 72.4% surveyed farmers in Guadalcanal and 51.4% in Malaita thought chicken meat was sometimes important food for them, while only 18.8% of Western Province farmers thought so (P<0.01). 55.2% surveyed farmers in Guadalcanal thought chicken eggs was sometimes an important food, while only 29.7% of Western Province farmers and 31.3% in Malaita thought so (P<0.05). 69% surveyed farmers in Guadalcanal thought pigs was sometimes an important food, while only 6.3% of Western Province farmers and 10.8% in Malaita thought so (P<0.01). Most survey farmers in the three provinces thought food from the market was sometimes important (62.5-79.3%, P>0.05). Similar results were reported in using fishing for food (69-75.7%, P>0.05). 93.1% surveyed farmers in Guadalcanal and 86.5% in Malaita thought food from the store was sometimes important for them, while 93.8% of Western Province farmers did not respond to this question. When ask any other source food they had, only 2 respondents in Western Province answered; 5 in Malaita and no one in Guadalcanal answered this question (Figure 38).

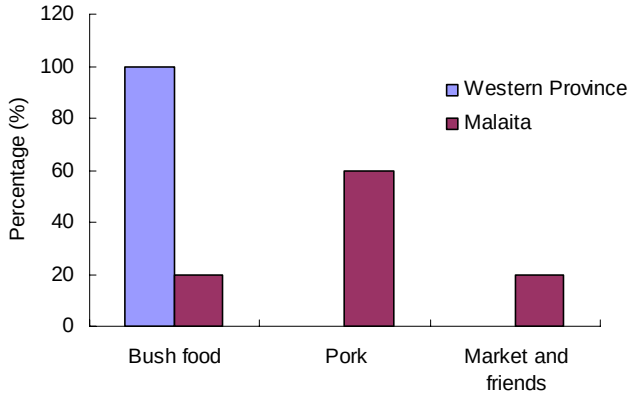


Figure 38. Other sources of food.

Keeping village chickens: 50-71% of respondents in the last 12 months kept village chickens in the three provinces (P>0.05) (Figure 39). 66.7-100% of respondents were aware of farmers who kept village chickens in the three provinces (P>0.05).

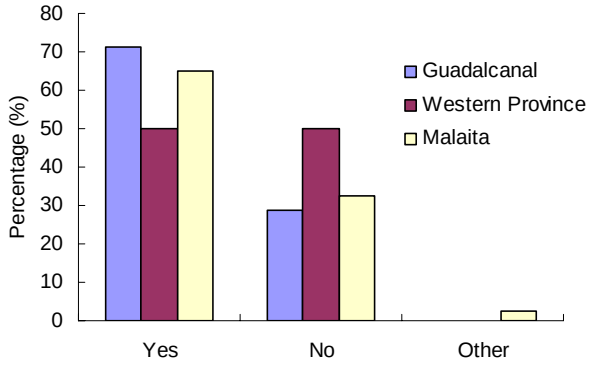


Figure 39. People who keep village chickens.

The reasons for not keeping village chickens varied in the three provinces (Figure 40).

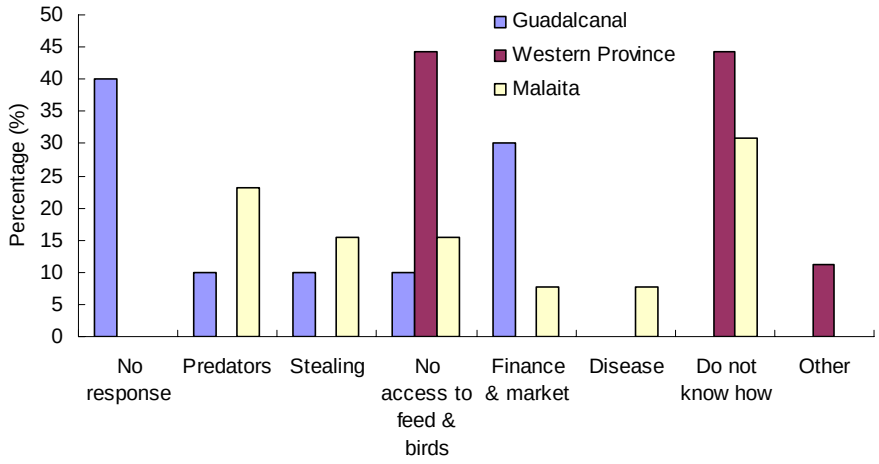


Figure 40. The reasons villages do not keep village chickens.

When asked are you thinking about starting to keep village chickens, 88.9% in Western Province and 100% in Malaita said yes, while 50% in Guadalcanal said yes, 20% said no and 30% did not respond. There were a few needs required for starting to keep villages chickens in the three provinces, but there were not significantly (P>0.05) different between the provinces (Figure 41). No access to feed and birds was low in Guadalcanal (10%), Medium in Malaita (15.4%) and high in Western (44.4%).

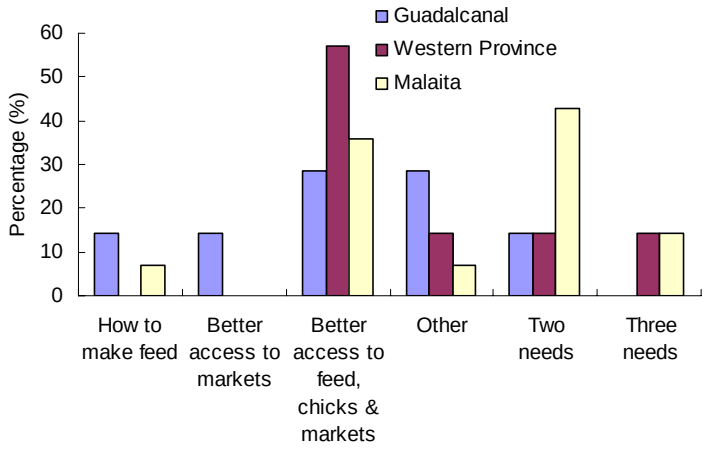


Figure 41. Help needed to start keeping village chickens.

Note: Two needs were a combination of better access to feed, chicks and markets, credit and other. Three needs were a combination of how to make feed, better access to markets, better access to feed, chicks and markets, credit and other.

Most of the respondents in Guadalcanal (83.3%) and Malaita (84.6%) kept chickens in the past, while 44.4% in Western Province had kept chickens (P<0.05). The reasons why villages stopped keeping chickens was due to predators, theft and management (Figure 42). Guadalcanal households were more concerned with the market (30.6%) while predators were a bigger problem in Malaita but low elsewhere.

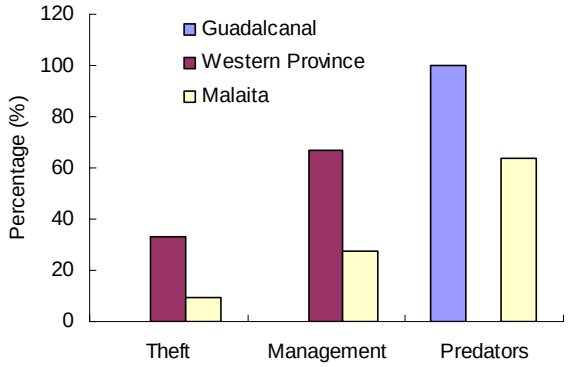


Figure 42. The reason why villages stopped keeping chickens.

Chicken: Currently in Guadalcanal farmers keep from 1 to 33 birds (1-8 hens, 1-6 roosters, 2-22 chicks), in Western Province farmers keep from 2 to 37 birds (1-13 hens, 1-10 roosters and 5-21 chicks), while in Malaita farmers keep from 1 to 53 birds (1-30 hens, 1-10 roosters and 1-41 chicks). Only 1-10 birds were sold in Guadalcanal, 2 birds were sold in Western Province and 1-20 birds were sold in Malaita in the year of the survey. However, 95.2-100% of the farmers in the three provinces did not keep sale records. When asked has the number been increasing or decreasing since Christmas, 44% in Guadalcanal, 75% in Western Province and 69.6% in Malaita had increased their numbers but there was no significant (P>0.05) difference between provinces. 66.7-91.3% of the respondents knew village chickens were in demand (p>0.05) in the three provinces (Figure 43). The main buyers were villagers (56.3%) and schools (37.5%) in Guadalcanal, Company, Vanga RTC (50%) in Western Province and villages (76.5%) in Malaita (Figure 44)

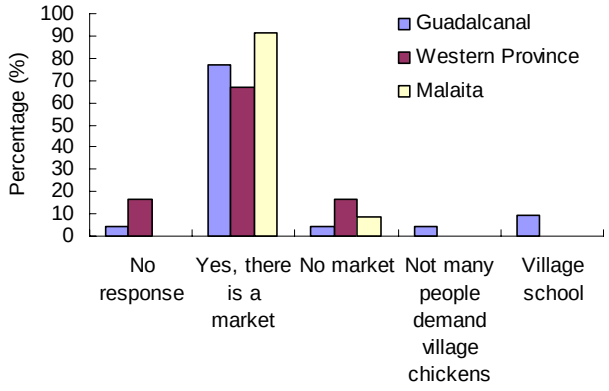


Figure 43. Market for village chickens.

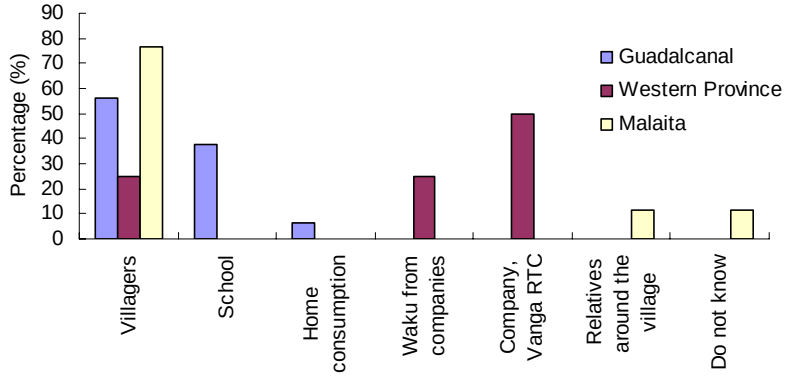


Figure 44. The main chicken consumers.

There was no significant difference between provinces. Meat is the main product traded (94%) with eggs being sold by only 2% of households and eggs and meat by 2% (4% for eggs in total). Each local rooster costs 20-25 (SI$) in Guadalcanal, 30-50 (SI$) in Western Province and 20-30 (SI$) in Malaita. Each hen costs 10-25 (SI$) in Guadalcanal, 20-40 (SI$) in Western Province and 20-30 (SI$) in Malatia (Figure 45). The cost of young chicks was 0-10 (SI$) in Guadalcanal, 5 (SI$) in Western Province and 5-10 (SI$) in Malaita.

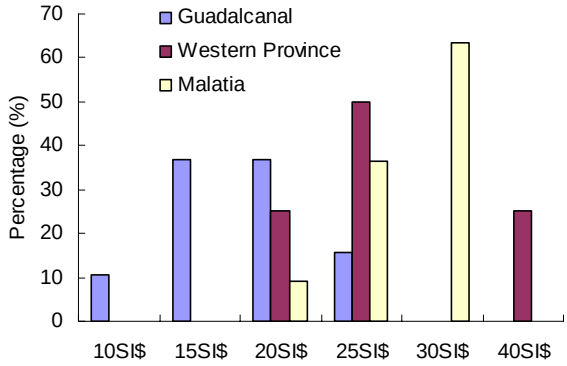


Figure 45. The cost for village hens in provinces.

Purpose: There were multiple reasons for farmers in the three provinces to keep a village chicken (Figure 46). There was no significant (P>0.05) difference between provinces.

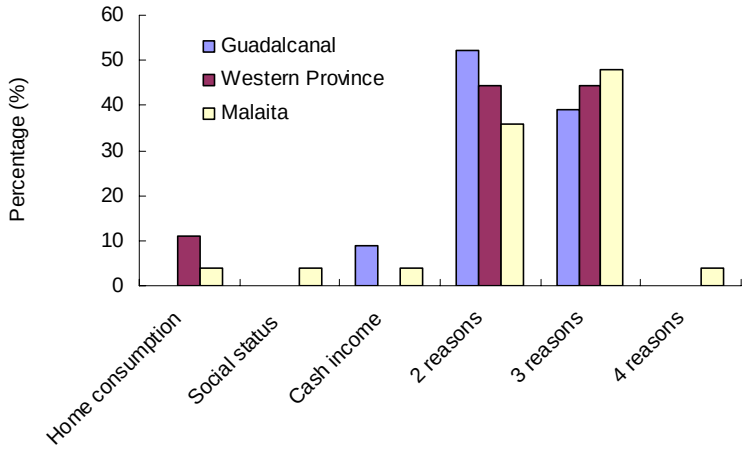


Figure 46. The reasons why farmers keep village chickens.

Note: 2 reasons=a combination of two reasons of the following (home consumption, social status, cash income, roosters for fighting and other (no specification)); 3 reasons=a combination of three reasons of the following reasons (home consumption, social status, cash income, roosters for fighting and other); 4 reasons=a combination of four reasons of the following (home consumption, social status, cash income, roosters for fighting and other).

The earliest that farmers started keeping village chickens was 10 years ago, the latest was last year in the three provinces (Figure 47).

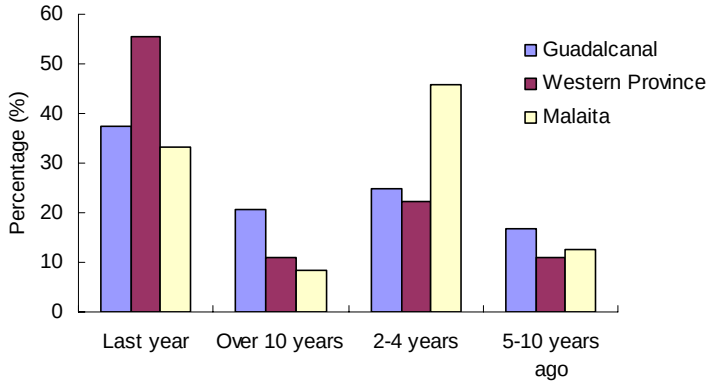


Figure 47. Years villages have been farming chickens.

When asked did anyone help you get started, 30.4% in Guadalcanal, 75% in Western Province and 56.5% in Malaita said yes. Most of the help was from family members (Figure 48). 66.7-75% of helpers were males.

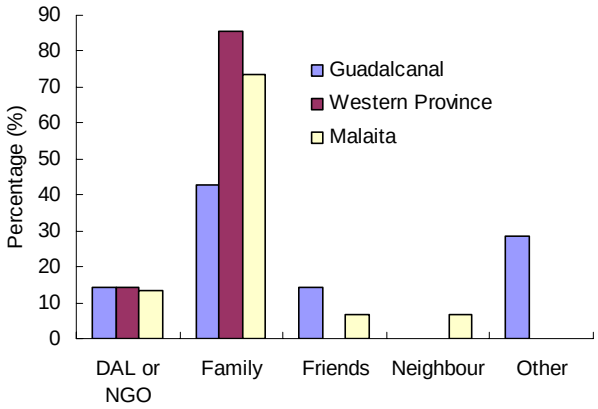


Figure 48. The sources of help given to farmers to start keeping chickens.

Housing: Common roosting places were the chicken house, trees, home or combination of these places. 61.9% of the respondents in Guadalcanal said chickens roosted in trees, 60% of surveyed farmers in Western Province said in a chicken house, and 45.8% the farmers in Malaita said chickens roosted in a combination of two of these places (chicken house, trees, home, on the ground and other (no specification)) (Figure 49). Overall there are more poultry houses in Western (60%), followed by Guadalcanal (14.3%) and Malaita (12.5%).

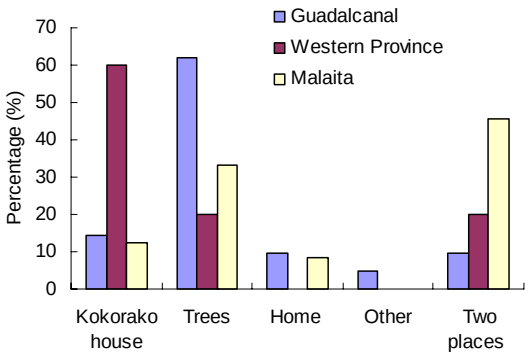


Figure 49. The places chickens roost.

Most surveyed farmers (50-100%, P>0.05) in the three provinces had a chicken house for chicks, but in Malaita chicken mainly roosted in trees, in the kitchen, under the house and other (not specified) (Figure 50). 85.7-100% (P>0.05) of the houses were built from local materials including leaves. 20% and 23% of houses in Malaita and Guadalcanal respectively were made with 'copper' (corrugated iron) roofing which there were none with this type of roofing in Western.

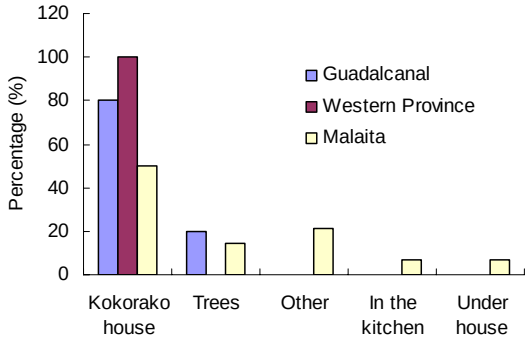


Figure 50. Housing situation in the three provinces.

The roof materials used were copper, leaf and bamboo in Guadalcanal, only leaf was used in Western Province and Copper and leaf were used in Malaita. The wall materials include bush sticks, bamboo, wire and other in the three provinces. The floor materials include earth (25, 100 and 54.5% for Guadalcanal, Western Province and Malaita respectively; P>0.05), timber (25 and 27.3% for Guadalcanal and Malaita respectively; P>0.05). Only Malaita uses cement as flooring (9.1%). The litter materials were used in the three provinces are leaves, sand, sawdust, grass and other (P>0.05) (Figure 51).

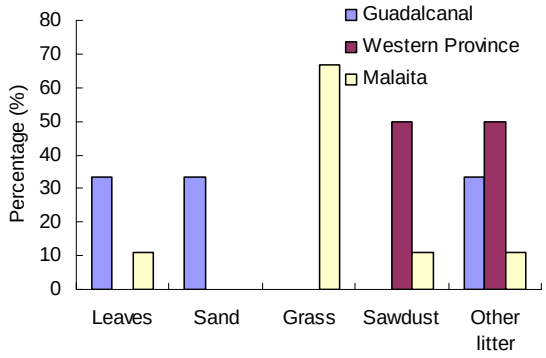


Figure 51. Litter materials.

When asked how often do you replace the litter, 50% in Guadalcanal and 50% in Western Province and 64.3% in Malaita said they never replace the litter (Figure 52). 50% of surveyed farmers replace litter every 1-2 weeks, 50% in Western Province farmers said they replacing litter every 1-2 days. Only 7.1% of Malaita farmers replaced litter every 1-2 days and 21.4% of surveyed farmers in Malaita said they replace litter every 1-2 months. There was no difference (P>0.05) in litter replacement between the three provinces.

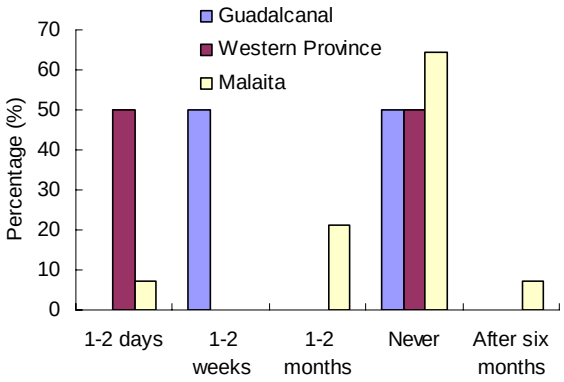


Figure 52. The frequency litter was changed.

Most of Guadalcanal (66.7%) farmers use the litter on garden; only 13.3% of Malaita farmers used litter on garden. 50% of Western Province farmers (n=2) sell litter, 20% of the surveyed farmers in Malaita gave the litter away (Figure 53).

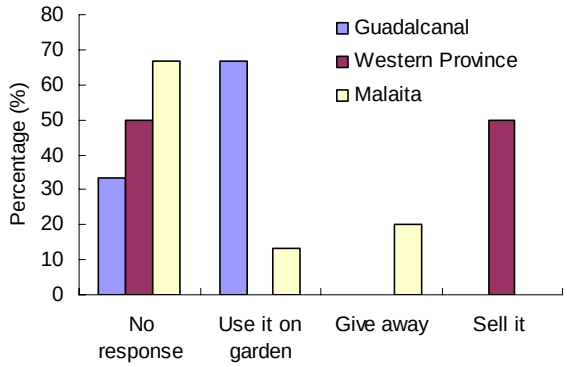


Figure 53. The ways litter was used.

Eggs are laid in different places include the chicken house, in the family house, in the kitchen, in bush a combination of these places in all provinces. There was a significant different (P<0.05) between Guadalcanal and Malaita, but no significant differences (P>0.05) between Guadalcanal and Western Province or between Western Province and Malaita. Western Province reported the highest percentage of egg laying in poultry houses (37.5%) followed by Guadalcanal (15.8%) and Malaita was very low at 4.3%. Family house and kitchen were the most common places for egg laying in Guadalcanal (31.6%/26.3%), Western Province (25%) and Malaita (13/4.3%). Malaita had the highest scores for 2 or 3 different places for egg laying (26.1/30.4% for 2 and 3 places respectively). This indicates they are moving around more and less managed than in other locations. It may also be related to cooler upland climate at Malaita (Figure 54).

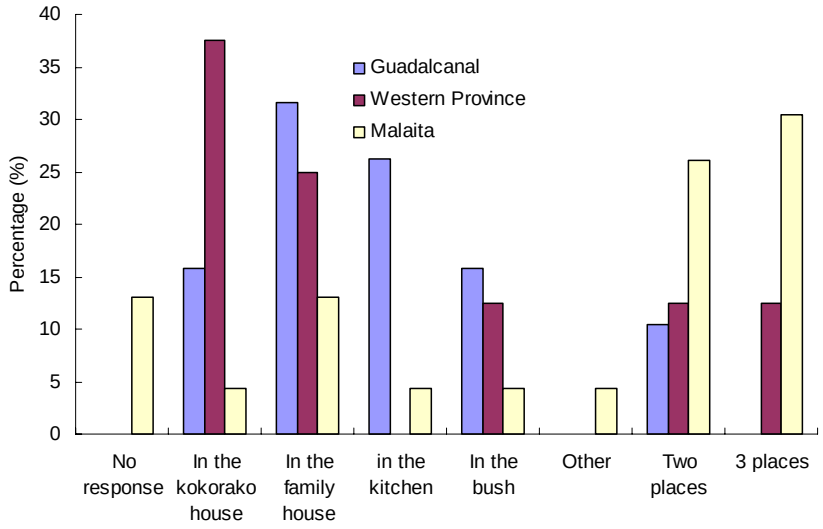


Figure 54. The places hens lay eggs.

n asked when the chicks hatch how to care for them, 62.5% of surveyed farmers in Western Province, 36.4% in Malaita and 16.7% in Guadalcanal observed hatching carefully (Figure 55). 38.9% in Guadalcanal, 31.8% in Maliata and 12.5% in Western Province did nothing. 27.8% in Guadalcanal, 25% in Western Province and 4.5% farmers in Malaita gave birds extra food. 18.2% surveyed farmers in Malaita and 16.7% in Guadalcanal confined the bird. There was no significant (P>0.05) difference between the three provinces.

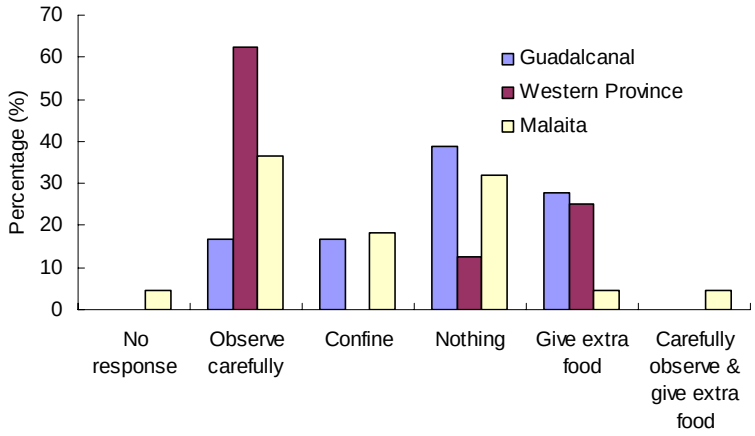


Figure 55. The ways farmers cared for birds when hatching.

There were no response given on brooding system used in Guadalcanal and Western Province, only 14.3% of surveyed farmers in Malaita had a brooding system using paper cartons. Period for brooding in this province was two weeks. 33.3% of farmers covered the brooder at night, 33.3% did not and 33.3% of surveyed farmers did not respond. 25% of these farmers used kerosene to heat the brooder, 25% of these farmers did not use a heater and 50% did not respond.

Economic

Most of surveyed farmers (66.7% in Guadalcanal and 92.9% in Malaita; P>005) collected local materials to build a chicken house. 7.1% of surveyed farmers in Malaita bought the materials. Only one farmer surveyed in Western Province bought the materials to build a chicken house (Figure 56).

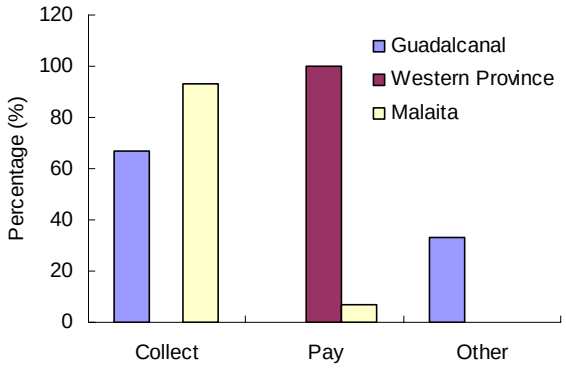


Figure 56. The ways farmers obtained materials for building their chicken house.

Water: 72.7% in Malaita, 68.4% in Guadalcanal and 28.6% of surveyed farmers in Western Province allow the birds to find the water by themselves, 26.3% of surveyed farmers in Guadalcanal, 27.3% in Malaita and 71.4% in Western Province gave chicken water in containers (P>0.05) (Figure 57).

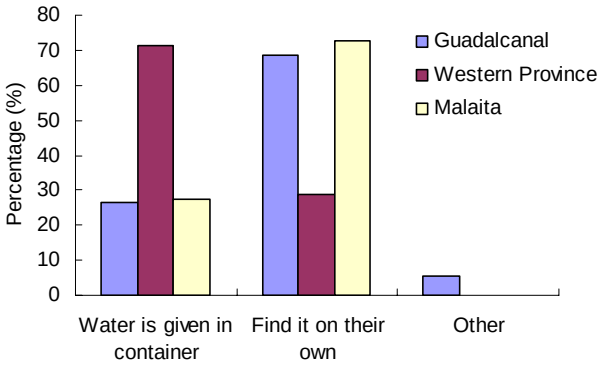


Figure 57. The ways birds obtain water.

Water sources are the local water supply, river, pool and from a rain water tank (P>0.05). Town water supply is the main water source in the three provinces, 57.1% in Malaita, 60% in Guadalcanal and 83.3% in Western Province (Figure 58).

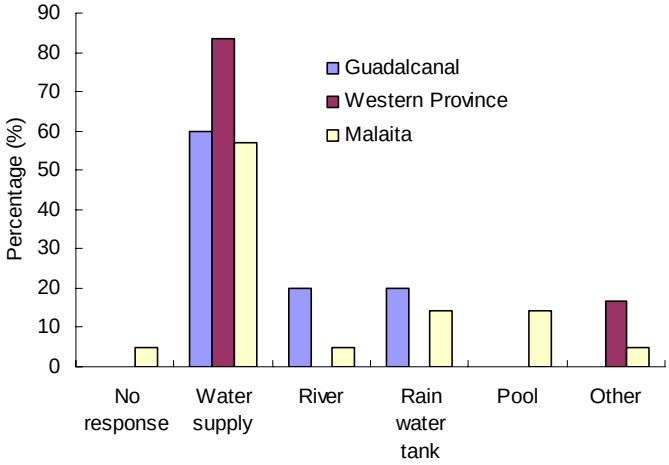


Figure 58. Water sources.

The water containers are used plastic dishes, bamboo, coconut shell and a commercial drinker (P>0.05). Plastic dish were used by 33.3% Guadalcanal, Malaita farmers and by

16.7% the Western Province farmers. Bamboo drinkers were used by 50% of farmers in Guadalcanal, 83.3% in Western Province and 16.7% in Malaita. Only Malaita farmers used commercial drinker with 16.7% of farmers using them (Figure 59).

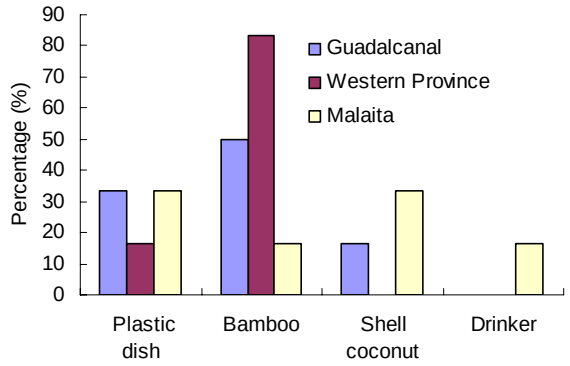


Figure 59. Types of water containers.

Feeding: The main feed in Guadalcanal (61.9%) and Malaita (70.8%) was fresh coconut, while the main feed in the Western Province were food scraps (55.6%). 25% and 38.1% of surveyed farmers fed chicken food scraps in Malaita and Guadalcanal respectively. 4.2% and 11.1% of surveyed farmers in Malaita and Western Province respectively let the chickens obtain food while free ranging. There was no significant difference (P>0.05) between the three provinces in sources of feed (Figure 60).

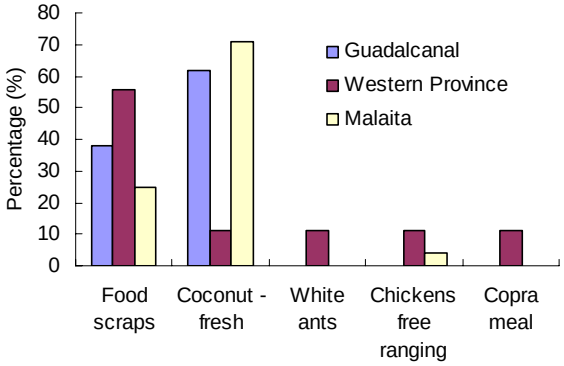


Figure 60. The main sources of food.

Other feeds included left over food (42.9% in Guadalcanal, 20% in Western Province, 25% in Malaita), coconut plus fruit and vegetables (42.9% in Guadalcanal, 40% in Western Province and 65% in Malaita) and insects (14.3% in Guadalcanal, 40% in Western Province and 5% in Malaita) (Figure 61).

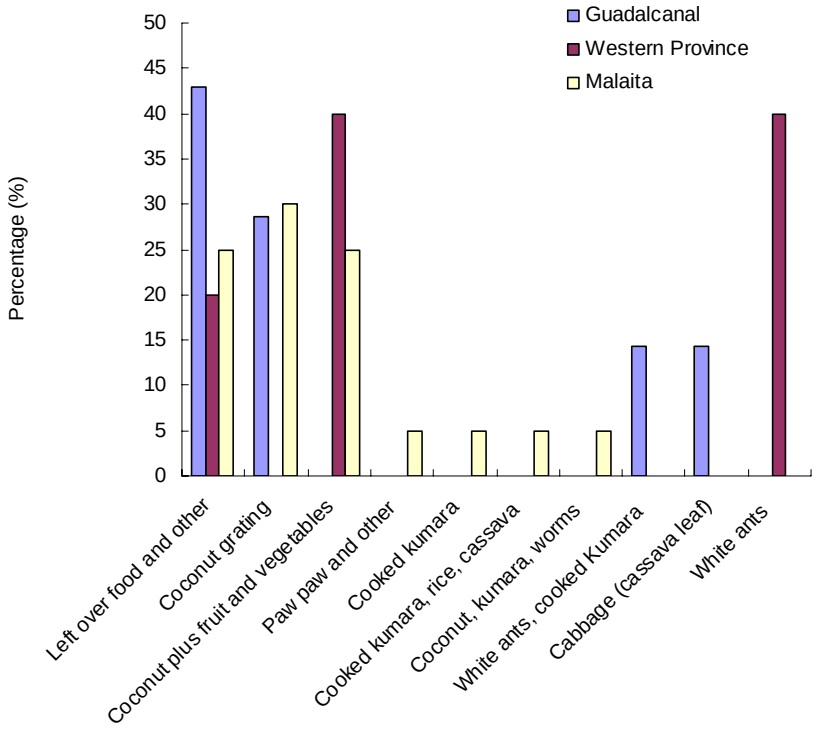


Figure 61. Other sources of feed.

Village chickens were observed eating grass and insects (88.8% in Guadalcanal, 87.5% in Western Province and 95.3% in Malaita; P>0.05). Chicks also ate left over food/compost and coconut in Guadalcanal, coconut in Western Province and rice and chilly in Malaita. Only a small percentage of farmers transport feed (25% in Guadalcanal by public transport, 50% in Western Province by own family or labour and 19% in Malaita by own family or labour) (Figure 62).

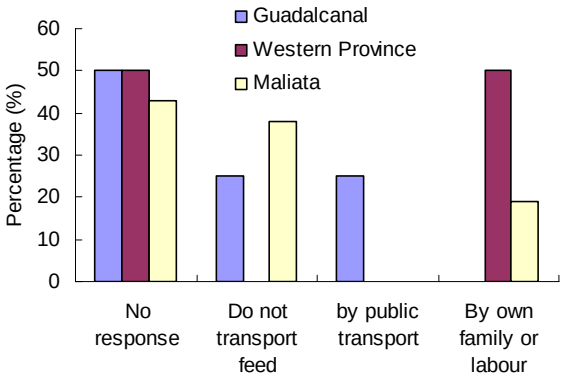


Figure 62. The ways farmers transported feed.

When ask how often do you feed chicks, most surveyed farmers fed twice a day (40% in Guadalcanal, 87.5% in Western Province and 81.8% in Malaita; P>0.05), some farmers fed once a day; others fed birds occasionally or every few days and some farmers fed birds ad lib (Figure 63).

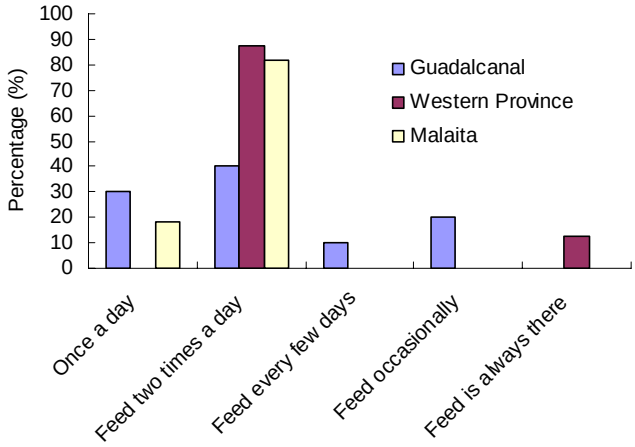


Figure 63. Frequency chicks were fed.

There was a significant (P<0.05) difference in feed preparation methods between Guadalcanal and Western Province, but no significant (P>0.05) differences between Guadalcanal and Malaita or between Western Province and Malaita. The main process used is scraping/cutting (62.5% in Guadalcanal, 16.7% in Western Province and 40% in Malaita). Other processes include cooking (12.5% in Guadalcanal and 15% in Malaita), mixing (12.5% in Guadalcanal and 10% in Malaita) and drying (6.3% in Guadalcanal and 5% in Malaita). Most of the surveyed farmers do not store feed (75% in Guadalcanal, 85.7% in Western Province and 69.6% in Malaita) (Figure 64)

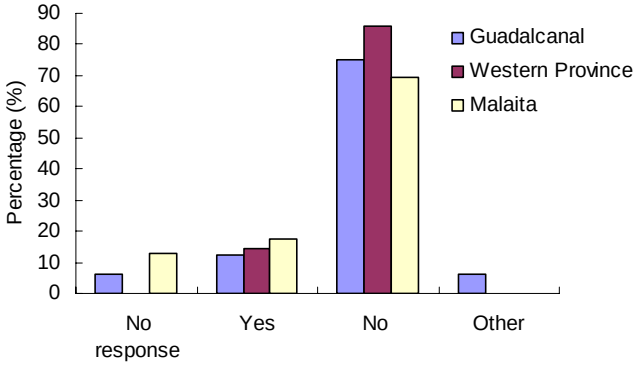


Figure 64. Feed storage method situation in the three provinces.

There was no significant (P>0.05) difference in feed storage methods between the three provinces. When farmers were asked when you store feed are there any losses, 50-75% of surveyed farmers do not respond this question in the three provinces. Feed losses came mainly from mould (25% in Guadalcanal), rats (50% in Western Province and 15.8% in Malaita) and wild birds (5.3% in Malaita).

Diseases or Deaths: It was common in the three provinces for chicken to sit on 8-12 eggs (62.5% in Guadalcanal, 55.5% in Western Province and 61.9% in Malaita; P>0.05) (Figure 65).

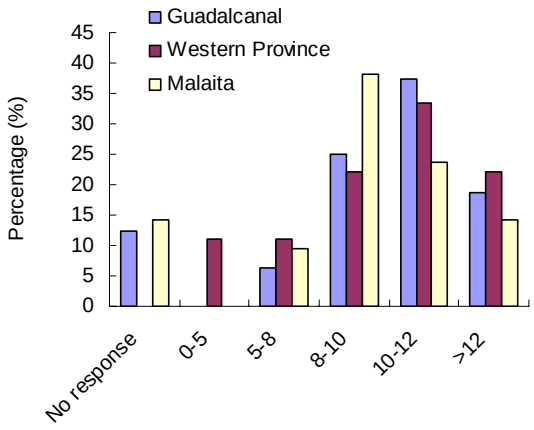


Figure 65. The numbers of eggs broody hens sit on.

The number of chicks hatched from one hen were 8-12 in Guadalcanal (63.1%), 8-12 in Western Province (42.9%) and 8-12 in Malaita (68.4%) (P>0.05) (Figure 66).

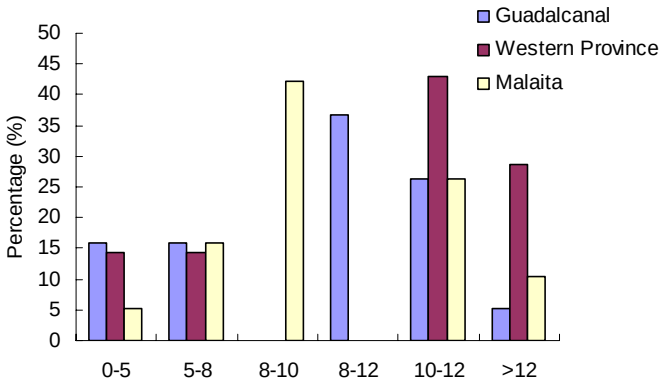


Figure 66. The numbers of chicks hatched from one hen.

In Guadalcanal, 1-5 chicks (83.3%) died from each brood, only 5.6% of surveyed farmers had no mortality, but 25% of surveyed farmers in Western Province and 30% in Malaita had no mortality. There was no significant (P>0.05) difference between the three provinces (Figure 67).

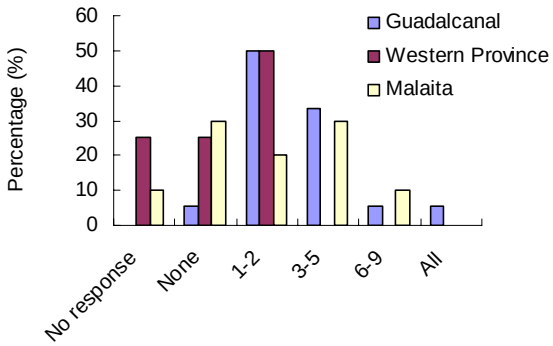


Figure 67. The numbers of birds which die in each brood of chicks.

There was a significant (P<0.05) difference between farmers from provinces when asked ‘how do you know if birds are sick’ in Guadalcanal and Western Province, but no significant (P>0.05) differences were found between Guadalcanal and Malaita and between Western Province and Malaita. Surveyed farmers knew the chick was sick by its

appearance (43.8% and 35.3%), not eating (37.5% and 23.5%) and diarrhoea (6.3% and 5.9%) in Guadalcanal and Malaita. 100% surveyed farmers in Western Province did not know if the chick was sick while only 12.5% of the surveyed farmers in Guadalcanal and 29.4% in Malaita do not know when chick was sick (Figure 68).

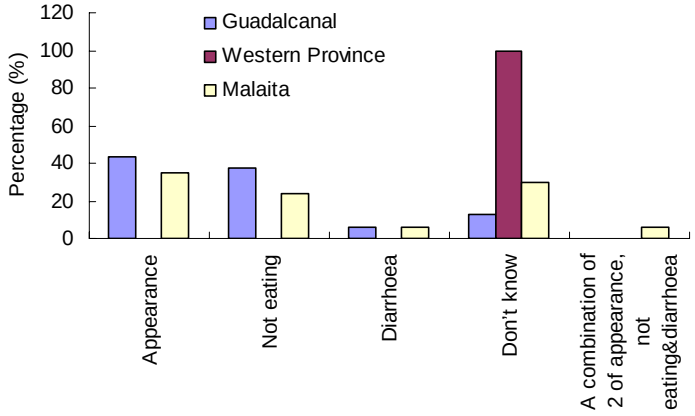


Figure 68. How farmers knew chickens were sick.

All surveyed farmers (100%) in Guadalcanal and most surveyed farmers (71.4%) in Malaita noticed different kinds of sickness such as closed eye, scabs on comb and legs (fowl pox), lice under feathers and scaly legs, but there was no significant (P>0.05) differences noted between the three provinces. 45% of surveyed Guadalcanal farmers eat sick birds. 45.5% of Malaita farmers, 33.3% of Western Province farmers and 15% of Guadalcanal surveyed farmers do nothing for their sick birds (Figure 69).

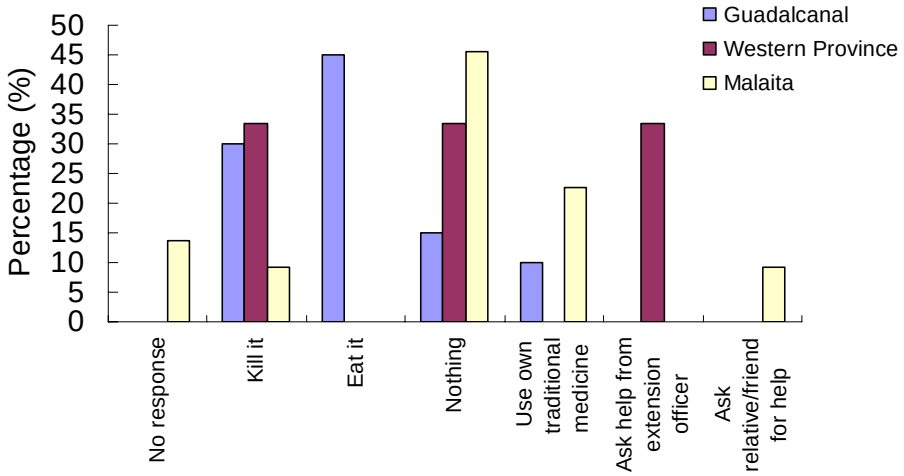


Figure 69. Methods used by farmers to treat sick birds.

Who does the work in looking after chicken? Most feeding was done by females (81.3%) in Guadalcanal, while males did feeding in Western Province (66.7%) and Malaita (63.6%). Providing water to birds was done by females (75%) in Western Province, while only 50% females did this job in Guadalcanal and 35% in Malaita (Figure 70). Some males provided water as well, 12.5% in Guadalcanal, 15% in Malaita and 25% in Western Province. There was no significant (P>0.05) in who did the feeding and watering in the three provinces.

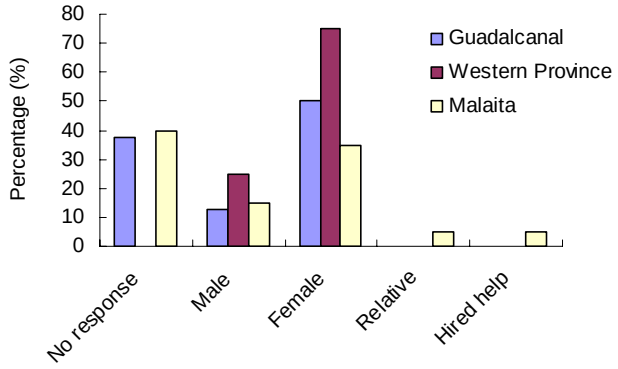


Figure 70. People provided water to birds.

50% and 61.1% of surveyed farmers in Guadalcanal and Malaita respectively did not answer the question on 'who cleans the rooms'. 50% of male and 50% of parents did the room cleaning in Western Province. 50% of female in Guadalcanal did the job. 5.6% male, 11.1% female, 5.6% parents and 5.6% of relatives performed the cleaning job in Malaita. 60%, 50% and 47.4% of surveyed farmers in Guadalcanal, Western Province and Malaita respectively did not answer the question 'who cares for the sick birds'. 50% of males cared for the sick birds in Western Province and both male and female shared the job in Guadalcanal and Malaita (Figure 71).

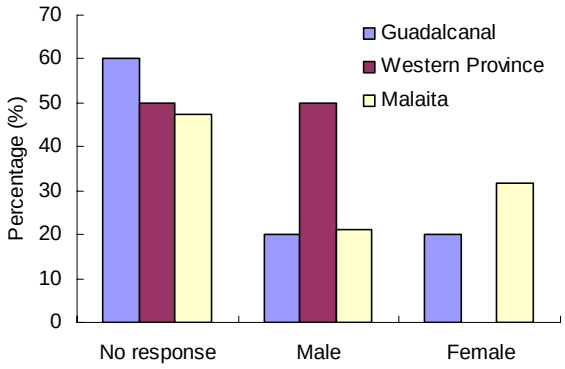


Figure 71. People who care for sick birds.

When asked who bought the feed and chicks, 100% of surveyed farmers in Guadalcanal and Western Province and 83.3% in Malaita did not answer this question ($P>0.05$). Only 11.1% male and 5.6% of male bought feed and chicks in Malaita. There was a significant ($P<0.01$) difference in selling birds between Guadalcanal and Malaita, but no significant ($P>0.05$) difference between Guadalcanal and Western Province and between Western Province and Malaita. 75% of females did the selling of chicks in Guadalcanal, while 66.7% of male did it in Western Province, 57.9% of surveyed farmers in Malaita did not respond this question (Figure 72).

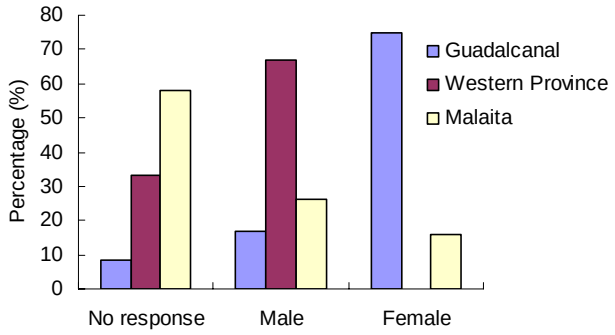


Figure 72. People who sell the chicks in the three provinces.

When asked who does transport the chickens, 100% of surveyed farmers in Guadalcanal and 83.3% in Malaita did not respond to this question (P>0.05). 100% of males in the Western Province transported the birds. 5.6% of males, females and hired help each transported birds in Malaita.

Selling: 47% of females in Guadalcanal made decisions went to sell, while only 36.4% in Malaita and 20% of Western Province females made the decision (P>0.05). 40% of males in Western Province and 36.4% of males in Malaita sell chickens, only 10.5% of males in Guadalcanal made a decision for selling the birds. Parents, husband and wife, relatives and all the family were involved in making decisions on selling (Figure 73).

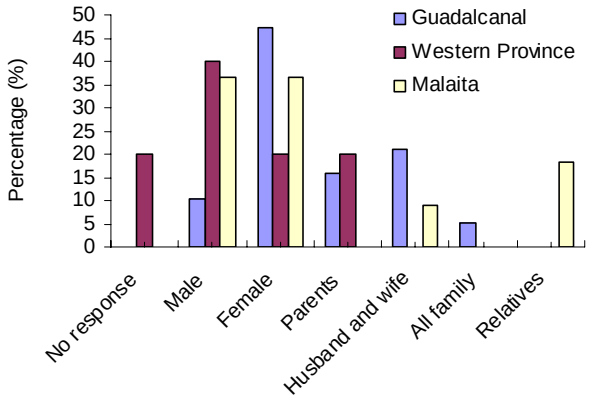


Figure 73. People who make decision on selling birds.

When asked who decides on the price, family members, chief, relatives, bird size and market decided the price of a bird in the three provinces (P>0.05). Females (26.3%) and the market (31.6%) are the main factors determining the price for Guadalcanal, while males (40%), parents (20%) and market (20%) are factors affecting the price for Western Province, Females (27.3%) and parents (27.3%) were the main decision makers on price in Malaita (Figure 74).

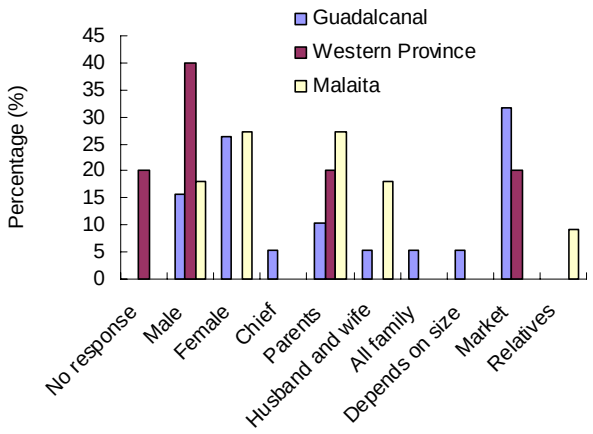


Figure 74. Factors and persons influencing the bird price.

There are a number of factors affecting the price of birds such as size of a bird, current market price, family members and competition with other producers. However, current market price and size of production are the main factors for the three provinces (P>0.05) (Figure 75). Other factors probably refer to a combination of need and opportunity to sell. Western Province had significantly higher external marketing at 50% while Malaita was only 5.6% and Guadalcanal 26%. This result is surprising in Malaita as the provincial centre is walking distance (5 hours) or a short truck ride from the survey area. Most marketing is done in the village at home (59.6%) followed by local markets (14.9%). Only 4.3% of households take poultry to provincial centres and 2.1% to Honiara.

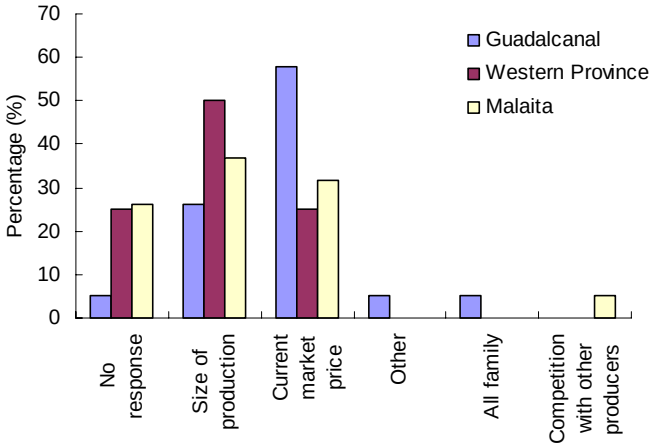


Figure 75. The factors affecting the price of birds.

There was a significant (P<0.05) difference in time when selling birds between Western Province and Malaita, but no significant (P>0.05) difference between Guadalcanal and Western Province or between Guadalcanal and Malaita. Selling was based on other reasons (40%, not specified) for Western Province. However, selling was mainly based on weight of birds and market demand in Malaita. There was 12.5-26.3% of surveyed farmers did not respond to this question (Figure 76).

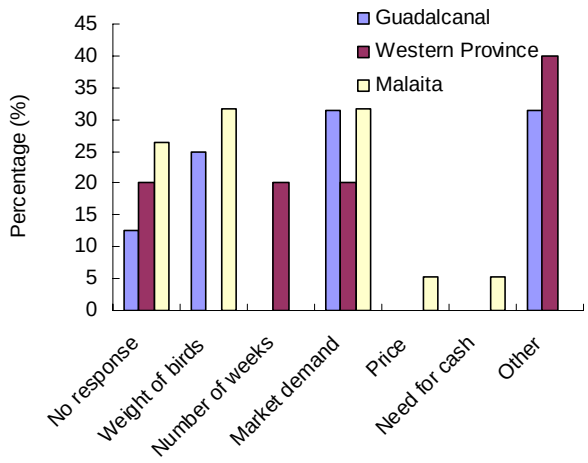


Figure 76. Time for marketing birds in the three provinces.

There was a significant (P<0.05) difference in marketing between Guadalcanal and Malaita, but no significant (P>0.05) difference between Guadalcanal and Western Province or between Western Province and Maliata. The common place for selling birds in Guadalcanal (63.2%) and Malaita (72.2%) was at home or in the village. In Western Province, the local market was the common place for selling birds (50%), farmers also sold birds at home or in the village (Figure 77).

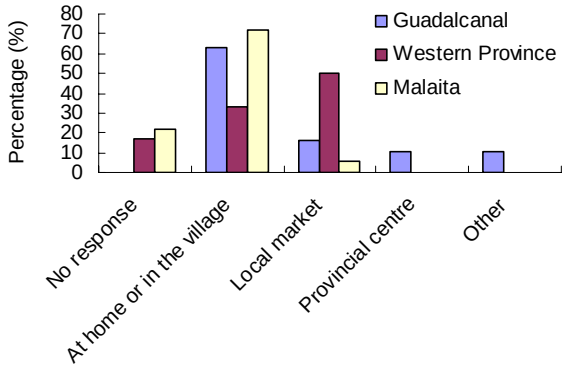


Figure 77. The places farmers sell the birds in the three provinces.

Villages (21.1%), schools and colleges (63.2%) are the main chicken buyers in Guadalcanal, Schools and colleges (50%) and campanies (25%) were the main buyers in Western Province, but villages (80%) were the main buyers in Malaita (P>0.05) (Figure 78).

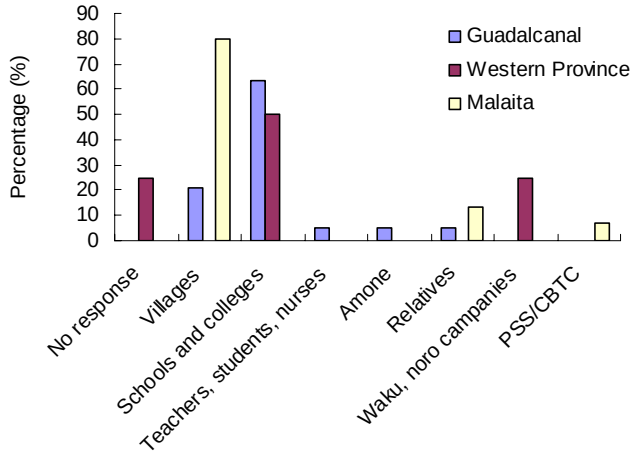


Figure 78. The main chicken buyers in the three provinces.

50% of surveyed farmers had no transport costs in Guadalcanal and Western Province, while 87.5% of surveyed farmers had no transport costs in Malaita (P>0.05). 50% of surveyed Western Province farmers had transport costs (Figure 79). However, no farmers answered the question on how much the cost of transportation was in the three provinces. Farmers go to markets not just to sell chickens, but also sell garden products and did other things as well as buying family needs (P>0.05) (Figure 80).

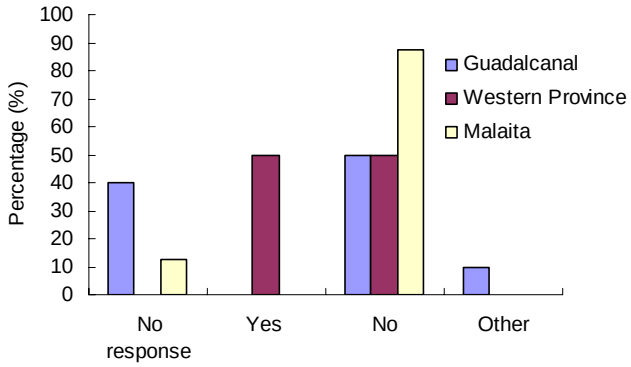


Figure 79. The transport costs to get birds to the market in the three provinces.

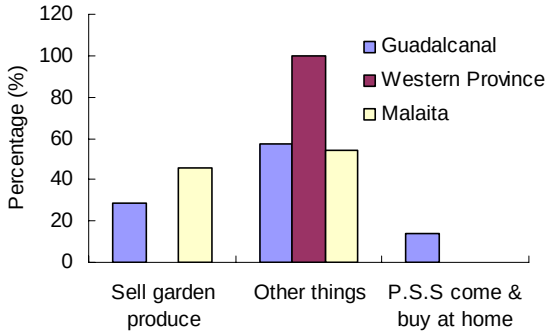


Figure 80. Reasons why farmers travel to the markets.

92.9% of surveyed farmers in Guadalcanal and 100% of surveyed farmers in Malaita spend their income on family essentials. However, 100% surveyed farmers in Malaita saved their income (P>0.05) (Figure 81).

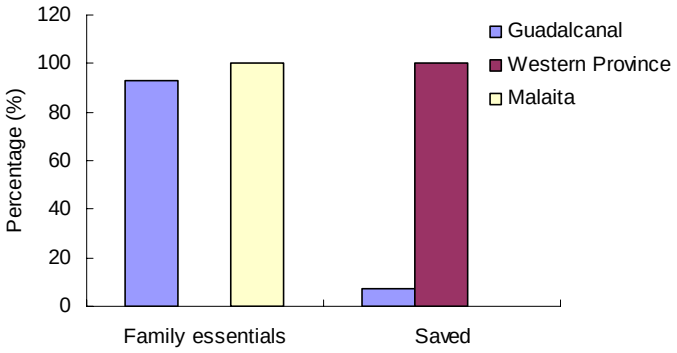


Figure 81. How did the farmers to spend their income.

Social problems: Most surveyed farmers (60-100%, P>0.05) in the three provinces suffered from social problems. These problems included demand for gifts (62.5 vs 37.5% in Guadalcanal, 66.7 vs 33.3% in Western Province and 42.9 vs 57.1% in Malaita; P>0.05). There was significant (P<0.05) difference between Guadalcanal and Malaita on jealousy problems (Figure 82). Jealousy was a more important factor in Guadalcanal (30%) than Malaita (10%).

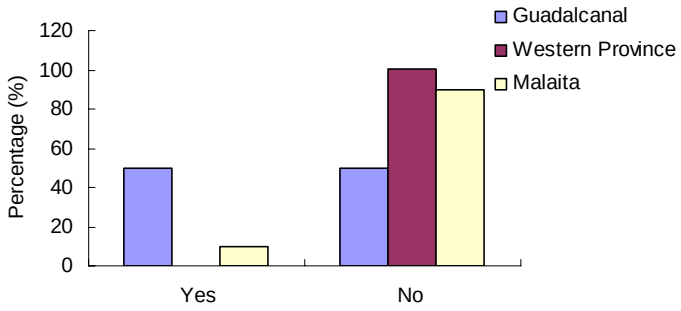


Figure 82. Jealousy problems in the three provinces.

There was a significant (P<0.01) difference between Guadalcanal and Malaita in theft problem, but no significant (P>0.05) difference were noted between Guadalcanal and Western Province or between Western Province and Malaita. 42.9% in Malaita, 87.5% in Guadalcanal and 100% in Western Province of surveyed farmers suffered from theft, only 12.5% in Guadalcanal while 57.1% in Malaita farmers did not suffer from theft. There was a significant (P<0.01) difference in disease between Guadalcanal and Malaita. Most surveyed farmers (80%) in Guadalcanal suffered disease problem in chickens, while there was no problem in Western Province and only 5.3% of surveyed farmers in Malaita suffered from disease in their chickens. 20% in Guadalcanal, 100% in Western Province and 94.7% in Malaita did not have disease problems with their birds. Another problem farmers suffered from was predators (Figure 83). Predators were rats, dogs, birds and snakes. Farmers may suffer from a combination of these predators, but there was no significant (P>0.05) difference between the three provinces. For example, 66.7% of surveyed farmers in Guadalcanal, 20% in Western Province and 57.1% in Malaita suffered from a combination of the predators.

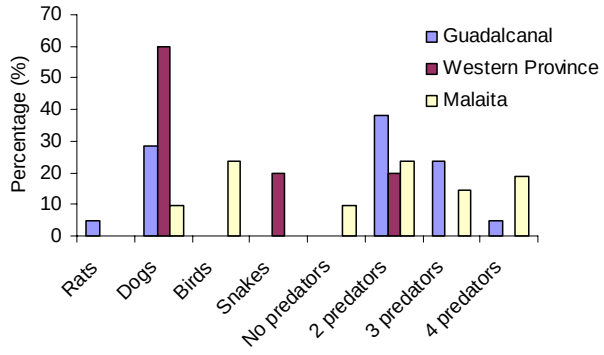


Figure 83. The predators of birds in the three provinces.

Help needed: 68.8% in Malaita, 69.2% in Guadalcanal and 100% in Western Province need help in feeding managements (P>0.05). 23.1% and 7.7% in Guadalcanal need help in housing and fencing and more practical information respectively. 12.5% in Malaita need help on feed types, disease recognition and treatment (Figure 84).

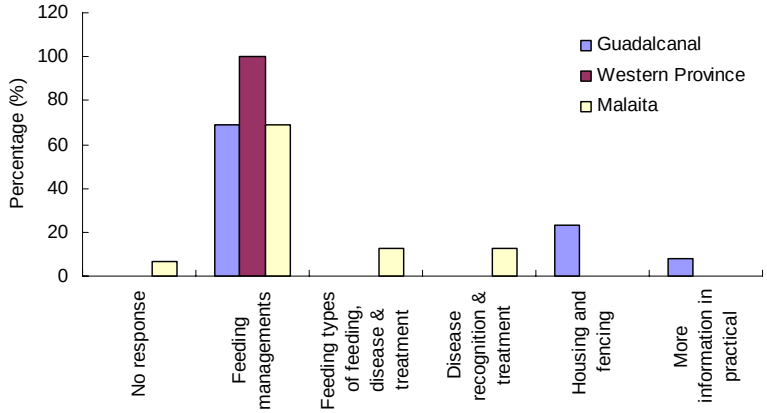


Figure 84. Information needed by surveyed farmers in the three provinces.

Farmers need training in housing (46.7% in Guadalcanal, 16.7% in Western Province and 25% in Malaita; P>0.05); feeding and management (33.3% in Guadalcanal, 33.3% in Western Province and 70% in Malaita) (Figure 85).

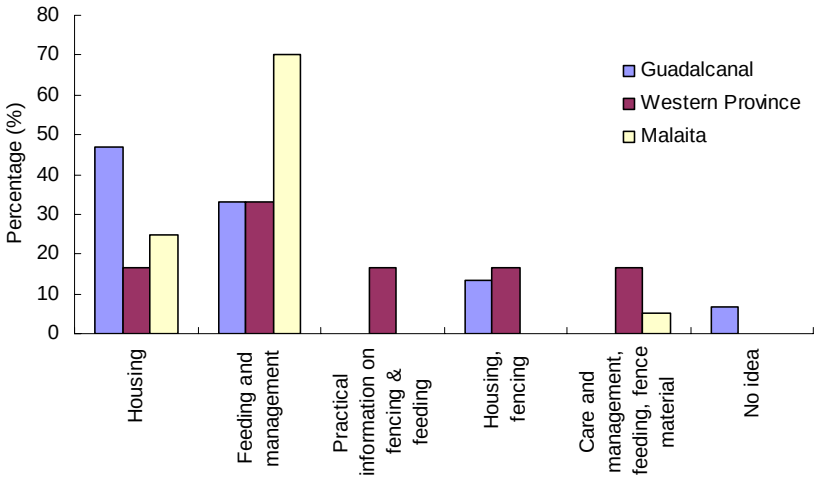


Figure 85. Training needed by surveyed farmers in the three provinces.

There was a significant (P<0.01) difference in getting information from MAL between Malaita and Guadalcanal and between Malaita and Western Province. No significant (P>0.05) difference was found between Guadalcanal and Western Province. 66.7% in Guadalcanal and Western Province respectively got information from MAL, however, only 5% of Mallaita got help from MAL. There was a significant (P<0.01) difference in getting information from NGO between Malaita and Guadalcanal and between Malaita and Western Province, but no significant (P>0.05) difference between Guadalcanal and Western Province. 25% in Guadalcanal and 73.7% of Malaita surveyed farmers did not get information from NGO. 50% of Guadalcanal surveyed farmers got information from Turusuala training centre, 25% of Guadalcanal, 83.3% of Western Province and 26.3% of Malaita surveyed farmers get information from KGA and 16.7% of Western Province farmers got information from Sausama FS (Figure 86).

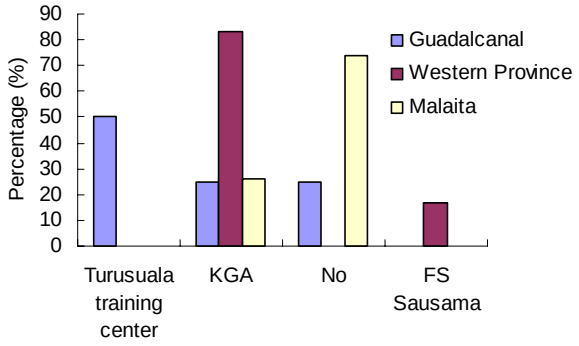


Figure 86. Where farmers obtained their information on poultry.

100% in Western Province and Maliata did not obtain any information from RTC. However, 87.5% of surveyed farmers in Guadalcanal did get information from RTC. Only Malaita farmers get information from friends and neighbours (23.8%). No information was obtained from Radio. If farmers do not get any information or help, why is this? There was a significant (P<0.01) difference on this question between Guadalcanal and Western Province or between Western Province and Malaita but no significant (P>0.05) difference between Guadalcanal and Malaita. 40% in Guadalcanal and 70% of Malaita surveyed farmers are not interest in obtaining information. 40% in Guadalcanal, 33.3% in Western Province and 30% in Malaita received no help. 10% in Guadalcanal surveyed farmers were lazy or there were not many people keeping chicken. 66.7% of surveyed Western Province farmers continue with looking after village chickens, but may not need more information (Figure 87).

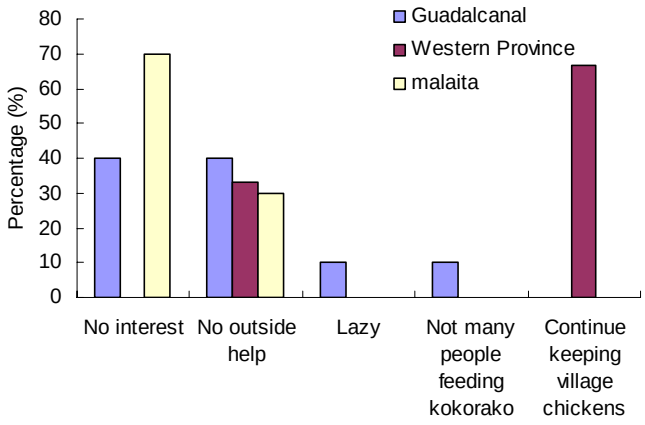


Figure 87. The reasons why farmers did not get information.

When asked would you like an extension agent to visit, 95.5% of farmers in Guadalcanal, 100% in Western Province and 95.7% in Malaita (P>0.05) would like an agent to visit. Only 4.3% of Malaita surveyed farmers would not like an agent to visit. Most surveyed farmers like an agent to visit once a month (45% in Guadalcanal, 16.7% in Western Province and 57.1% in Malaita; P>0.05) and once in 3-6 months (20% in Guadalcanal, 83.3% in Western Province and 23.8% in Malaita) (Figure 88).

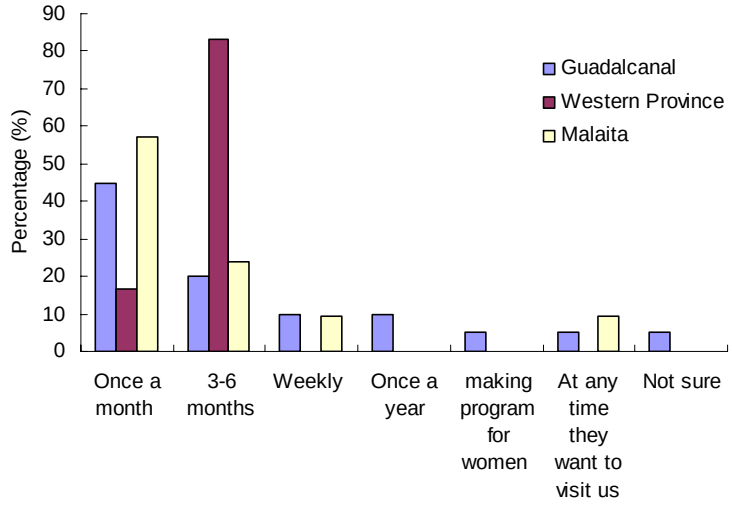


Figure 88. The frequency farmers would like an extension agent to visit.

Future plans: Most surveyed farmers (88.9% in Guadalcanal, 80% in Western Province and 88.9% in Malaita; P>0.05) would like to extend their farms (Figure 89).

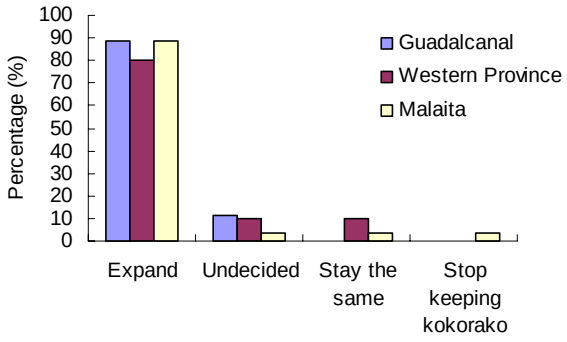


Figure 89. The future intention of surveyed farmers in the three provinces.

The reasons for the decision made are sales increase (26.1%) and income (43.5%) for Guadalcanal surveyed farmers, 71.4% of Western Province surveyed farmers want to extend their farm for income and 68% of Malaita farmers wish to extend farm for income and food. There was a significant (P<0.01) difference on the reasons for expansion between Guadalcanal and Malaita or between Western Province and Malaita; no significant (P>0.05) difference was found between Guadalcanal and Western Province (Figure 90).

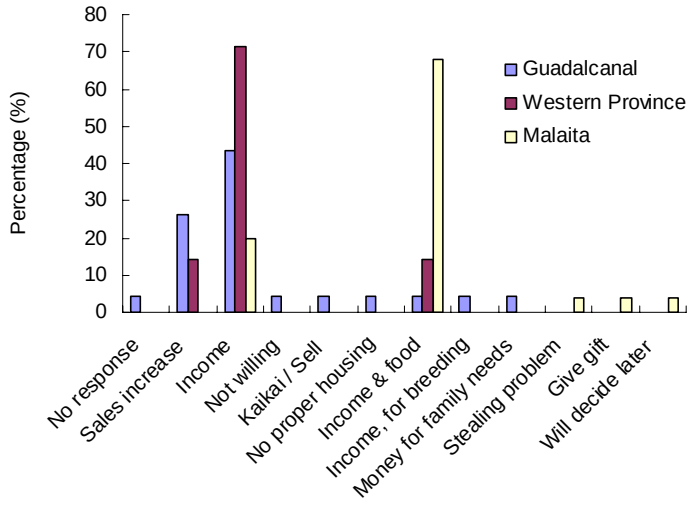


Figure 90. The reasons why farmers want to extend the farm.

Attitudes: When asked what do you think about keeping village chicken, 95.6% of Guadalcanal surveyed farmers think birds are easy to manage (47.8%) and keeping village chickens can increase income (47.8%). 75% of surveyed Western Province farmers think keeping broilers are good for income. 96.2% of Malaita surveyed farmers think they are easy to manage (50%) and good for income (46.2%). There was no significant (P>0.05) difference between the three provinces (Figure 91).

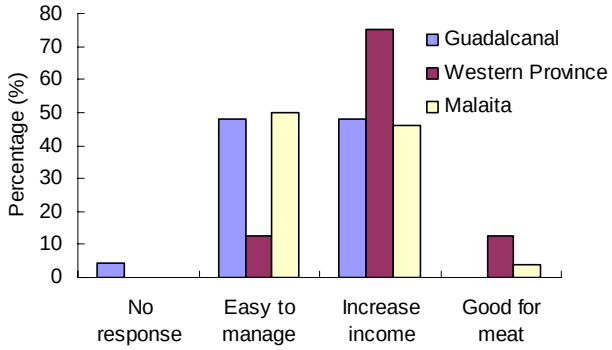


Figure 91. The good aspects of keeping broilers.

When asked what do you think is no good about keeping village chicken, 64.7% of surveyed Guadalcanal farmers think birds create mess, 50% of Western Province farmers think chickens are difficult to manage and 33.3% of this province farmers think birds create a mess, while 30.4% of surveyed malaita farmers thinks birds create a mess and 21.7% think they damage crops. There was a significant (P<0.05) difference in why is no good to keeping chickens between Guadalcanal and Malaita, no significant (P>0.05) difference between Guadalcanal and Western Province or between Western Province and Malaita (Figure 92).

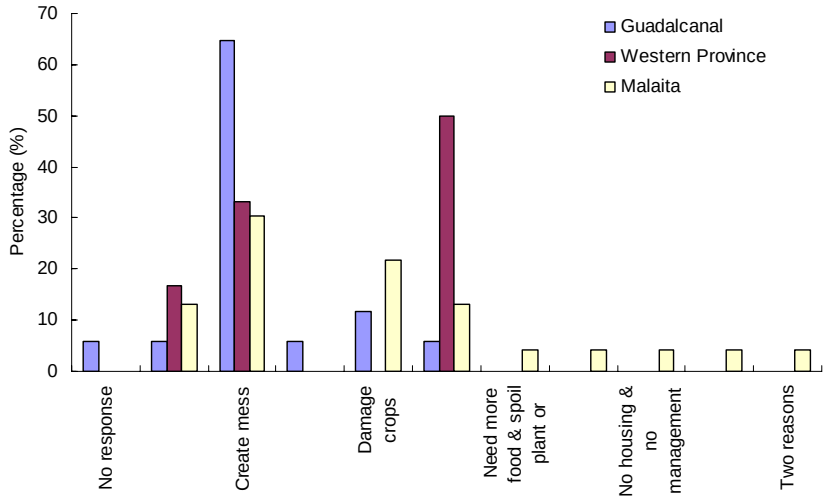


Figure 92. The reasons surveyed farmers think keeping broilers no good.

Discussion

Overall results: The aim of this survey is to obtain basic information on the current feeding practices and farmer attitudes to village poultry production and assess the possibility to use local feed to reduce feed cost and increase the profitability. Results showed that farmers thought most important income was from garden products, less important from chicken and egg production. Garden products were also important food sources and again chicken and eggs were less important for food. Over 62% of surveyed farmers kept chickens and 82.9% of surveyed farmers would like keeping chickens. The purposes for keeping broilers were for cash income, home consumption, social status and roosters for fighting. The main reasons for not keeping chickens were lack of knowledge and resources such as no access to feed and birds, do not know how, finance and market and predator. The respondents need better access to feed, chicks and markets, credit, fencing, housing and controlling stealing and predators to start keeping chickens. Most of surveyed farmers (66.7%) had a chicken house, trees, kitchen and under the house also were used for chickens. Most of materials for building chicken houses were collected freely. The main source of feeds for chickens were fresh coconut, food scraps, white ants, copra meal and fish meal. Free-range chickens were also an option to feed chickens. The main preparation of feed was scraping/cutting. Most of the farmers (64%) did not provide water for birds, let them find water themselves. Only 26% of surveyed farmers transported feed. Most of farmers knew the chicken was sick by appearance (37%), not eating (26%). Most of the work was done by family members including parents, kids and grandparents. Family members also made a decision on selling birds, on time to sell and on bird price. Most of the farmers faced more or less social problems (87.1% vs 12.9%), including demanding for gifts, jealousy, theft, diseases and predators. The main assistance needed for village chicken production was feeding management (76%), others including housing and fencing, feed types, disease recognition and treatments, more information on practical aspects. Currently there was little help available for farmers. All farmers would like to extension officer to visit them. The majority of farmers thought keeping broilers was good for income. Few farmers thought keeping chickens created mess, damaged crops and difficult to manage. In future most farmers would like to extend their farmers to increase income and food.

Province results: Income from chicken meat was not important for Western Province farmers (81.3%), or Malaita farmers (59.5%), but it was important for Guadalcanal farmers (58.6%). 50-80% of respondents in the three provinces thought about starting to keep village chickens. The needs for starting a chicken farm were similar for three provinces including how to make feed, better access to feed, chickens and markets. There was a

proper chicken house for chicken roosting in Western Province (60%), 61.9% of Guadalcanal farmers let the chickens roosted in trees and 45.8% of Malaita farmers let the chicken roosted in a combination of two of a chicken house, tree, family home and on the ground. The chicken houses were built by collecting local materials including leaves in three provinces. Farmers used local feed to feed chickens in the three provinces. The main feed in Guadalcanal (61.9%) and Malaita (70.8%) was fresh coconut, while the main feed in Western Province was food scraps. Village chickens were observed eating grass and insects as well. Most of farmers in Western Province (71.4%) provided water for chickens, while most of farmers in Malaita (72.7%) and Guadalcanal (68.4%) did not provide water for chickens and allowed them find water themselves. Most of farmers in Guadalcanal and Malaita knew the chicken was sick by bird's appearance, not eating and diarrhoea. However, 100% of surveyed farmers in Western Province did not know the bird was sick. Most of work for looking after chickens was done by females (81.3%) in Guadalcanal, while this was done by males in Western Province (66.7%) and in Malaita (63.6%). Family members were all involved in making decision on selling the birds, bird price and the time for selling of birds in the three provinces. The price of birds was also affected by the size and current market price. Most of surveyed farmers (60-100%) in the three provinces suffered from social problems. Farmers (80%) in Guadalcanal suffered disease problem in chickens, while there was no problem in Western Province and only 5.3% of surveyed farmers in Malaita suffered from chicken disease. The main help needed in the three provinces was similar to the over all results such as feeding management. Most of the surveyed farmers would like extension officers to visit them on regular basis. Most of surveyed farmers thought keeping chickens were easy and good for income, few farmers thought keeping chickens created mess, difficult to manage and damaging crops and flowers. Overall, majority respondents would like keeping chickens or extending their farmers for food and income and also had good attitude to keeping broilers. However, farmers were lack of knowledge how to manage and feeding chickens and little information on practical aspects of keeping village chickens were available for farmers.

11.3 Appendix 3: The performance of local chickens fed on locally available feed compared with a commercial layer diet

11.3.1 Introduction

Village chickens play important roles on improving the nutrition status and income for local small farmers. Village chickens are reported as an important source for provision of meat and eggs for home consumption in South African countries (Cairns and Lea, 1990; van Veluw, 1987; Kabatange and Katule, 1989; Andrews, 1990). Village poultry provide 19-50% of rural family income and contribute about 98% of egg and chicken meat consumed in the villages of developing countries (Sonaiya, 2007). However, feed cost account for about 60% of total production costs in the commercial poultry industry (Renkema, 1992). In addition, the village poultry production is low due to the poor genetic potential of the birds, inadequate feeding and management and the harsh environmental conditions (Pousga et al., 2005). In the Sri Lanka, the village chicken feed included 72% of household refuse, 13% of grass shoots, 8% of small metazoans and 7% paddy rice. In Ethiopia, analysis of the crop contents of the chickens showed a 40% of seed material (Ngesse, 1992).

There is little information about using local feed resources (unconventional feed resources) for village poultry production. The smallholder village poultry sector in the South Pacific comprises about 113,000 families with an average of 10 birds producing both eggs and meat for household consumption and sale in local markets. Improved use of local feedstuffs is seen as the best option to improve current low levels of production that are unable to meet the rising demand for eggs and meat. Local available feed could be a cheap source for village poultry production. Perez (1997) reported that the use of cassava and soybean forage in a 50:50 ratio ground together to substitute commercial feeds for layer feed to reduce feed cost. Integrated poultry into cropping system, particularly integrated into vegetable farming is another option (Baksh, 1994; Glatz et al., 2005a;b and Miao et al., 2005). This trail is conducted to study the performance of local birds fed on local available feed and on commercial diets.

11.3.2 Materials and methods

Experiment was conducted in at the Poultry Research Facility, located at the Solomon Islands College of Higher Education (SICHE). 8 pens were set up for 9 weeks trail. Total 64 local hens (collected from the local communities with different ages) were used, 8 located in each pen randomisely with four replications for each treatments. Experimental diet (Diet 1) was formulated according to nutrient requirement of hens recommended by NRC (1994) using local available feed ingredients (Table 1). A commercial layer diet was purchased in local market. Feed allowance was 100g/bird/day for Diet 1 and 100-125g/bird/day for a commercial diet. Whole seed of corn and mungbean was fed due to lack of grinding or soaking facilities. The Cassava and pawpaw were fed fresh and were prepared, weighed and mixed twice a day. Average body weight for birds in control was 1.49kg and 1.33kg for birds on Diet 1. Bird liveweight, egg weight, number of eggs laid, feed intake, feed residue were recorded. Commercial layer diet with minimum 16% of protein was bought from Lae Feed Mills Pty Ltd, Solomon Islands.

Table 1. The ingredients and estimated nutrient composition of diet 1.

Ingredients	Percentage
Corn	44
pawpaw fruits	5.4
mungbean	30
Fish meal	6
Cassava fresh	6.3
lime	8

salt	0.3
Total	100
Nutrient composition	
CP (%)	15.1
AME (MJ/kg)	10.8
Crude Fibre (%)	2.2
Ca (%)	3.07
P (%)	0.53
Available P (%)	0.17
Methionine (%)	0.32
Lysine (%)	0.54

Statistical analysis: A completely randomised design was used for the trial with the control group compared to treatment (Diet 1). The treatment effects were assessed with ANOVA in Systat software (Wilkinson, 1996). Bonferroni's post hoc was used to separate means only if significant main effects were detected by analysis of variance. Bonferroni's post hoc test is a multiple comparison test based on Student's t statistic and adjusts the observed significance level when multiple comparisons are made.

11.3.3 Results

Hens on Diet 1 had significantly (P<0.01) lower body weight at start compared to that of hens on a commercial, but it was increased from Week 3 to 8 (Table 2). Birds on Diet 1 had lower feed intake compared to birds on a commercial layer diet, particular in Week 1, 3 and 4 (P<0.01) (Table 2 and Figure 1). There was no significantly different in an egg weight between treatments. Average egg weight was 48.4 vs 48.2g for a commercial diet and Diet 1 respectively, but birds on the commercial diet produced more eggs (20.4 per week) compared to the birds on Diet 1 (10.3 per week) (Figure 2). Amount feed needed to produce 12 eggs was higher for birds on Diet 1 compared to that of birds on a commercial diet, particular in Week 2, 3, 5 and 6 (P<0.05).

Table 2. The performance of hens on Diet 1 and a commercial layer diet.

Date	Treatment	Body weight (kg)	Weight gain (g)	Feed Intake (g)	Egg weight (g)	No. of eggs	Egg (%)	Feed (g)/12eggs	FCE (%)
Week 1	Control	1.55	58.3	102.45	47.17	19.8	35.3	3705.0	16.2
	Diet 1	1.32	-10.8	63.07	46.34	12.3	21.9	3903.4	16.1
	P	0.003	0.049	0.006	0.807	0.163	0.163	0.825	0.979
	SEM	0.049	18.441	8.656	1.506	2.605	4.652	399.3	2.110
Week 2	Control	1.54	-14.3	87.8	48.5	25.2	45.1	2381.2	26.1
	Diet 1	1.32	2.3	59.8	47.7	10.8	19.2	4742.8	19.9
	P	0.012	0.643	0.139	0.671	0.002	0.002	0.308	0.484
	SEM	0.049	15.996	9.240	0.880	3.024	5.399	1077.6	4.045
Week 3	Control	1.55	15.2	116.2	49.3	22.8	40.6	3568.4	17.2
	Diet 1	1.38	57.6	76.4	49.3	9.3	16.5	8399.3	10.9
	P	0.040	0.169	0.000	0.956	0.019	0.019	0.150	0.199
	SEM	0.044	14.913	7.915	0.650	3.213	5.737	1634.1	2.334
Week 4	Control	1.60	43.6	91.5	48.8	21.5	38.4	3136.1	20.5
	Diet 1	1.39	11.5	72.0	49.2	11.3	20.1	4992.3	13.9
	P	0.012	0.464	0.003	0.834	0.081	0.081	0.200	0.251
	SEM	0.047	19.930	4.135	0.736	2.982	5.324	691.9	2.701
Week 5	Control	1.61	15.2	83.2	49.4	24.5	43.8	2425.1	26.0

	Diet 1	1.42	28.8	61.9	47.2	9.8	17.4	4272.6	13.4
	P	0.015	0.712	0.075	0.218	0.011	0.011	0.005	0.020
	SEM	0.044	16.478	6.115	0.831	3.372	6.022	401.8	3.017
Week 6	Control	1.60	-12.3	77.0	49.1	22.0	39.3	2501.3	24.4
	Diet 1	1.46	39.1	65.6	50.9	10.8	19.2	4251.1	14.5
	P	0.084	0.009	0.354	0.633	0.043	0.043	0.018	0.009
	SEM	0.041	11.566	5.662	1.728	2.939	5.249	416.0	2.214
Week 7	Control	1.61	10.7	84.3	46.1	17.3	30.8	6040.5	16.9
	Diet 1	1.47	10.7	71.9	47.1	10.5	18.8	4857.4	12.1
	P	0.065	1.000	0.181	0.785	0.270	0.270	0.730	0.391
	SEM	0.039	9.948	4.444	1.626	2.869	5.123	1532.7	2.591
Week 8	Control	1.62	9.8	81.0	47.5	15.8	28.1	3734.1	16.6
	Diet 1	1.50	30.3	70.4	46.9	7.5	13.4	9807.2	9.2
	P	0.143	0.628	0.448	0.879	0.093	0.093	0.251	0.104
	SEM	0.039	18.893	6.394	1.541	2.471	4.412	2494.5	2.286
Week 9	Control	1.61	-5.3	75.0	49.3	14.3	25.4	7618.4	15.0
	Diet 1	1.49	-12.8	65.4	48.9	10.5	18.8	5296.8	14.5
	P	0.163	0.795	0.383	0.808	0.649	0.649	0.535	0.956
	SEM	0.044	12.845	5.048	0.597	3.693	6.595	1689.4	3.448

Feed conversion efficiency (total egg weight produced weekly/total amount feed consumed weekly, FCE) was similar between different treatments at Week 1 and 9, but was lower for birds on Diet 1 compared to that of birds on control for rest of the weeks, particular in Week 5 ($P<0.05$) and Week 6 ($P<0.01$).

Fig. 1. Feed intake of layers fed diet 1 and commercial diet

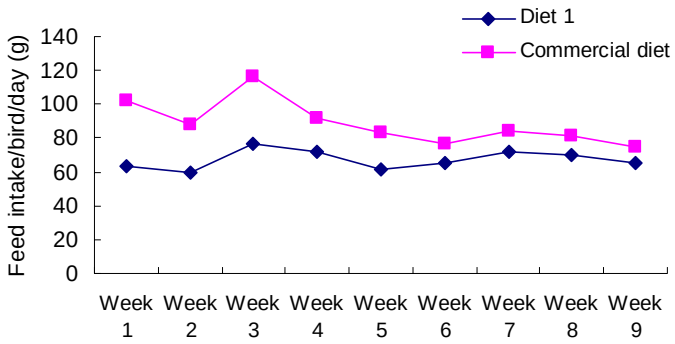
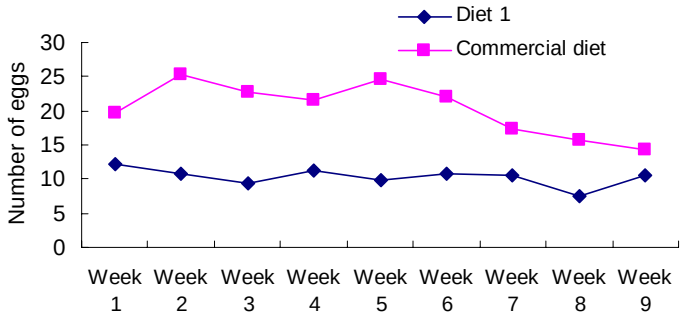


Fig. 2. Number of eggs laid per week for layers fed diet 1 and commercial diet



11.3.4 Discussion

Low egg production was found for local hens overall in current trail. However, hens fed on a commercial layer diet had better performance compared to hens on Diet 1. For example, amount of feed needed to produce 12 eggs was higher for birds on Diet 1 (5613.7g) compared to the birds on a commercial diet (3901.1g). FCE was higher for the birds on the commercial feed (19.9%) compared to the birds on Diet 1 (13.8%). It is well documented that village chickens have a low egg production. The average number of eggs per bird was 12.9 (n=160) (Dessie and Ogle, 2001). Average egg production was 3.1/hen/month in Sudan (Khalafalla et al., http://www.iaea.org/programmes/nafa/d3/public/9-village-khalafalla.pdf). Muchadeyi et al. (2005) reported that the chicken production potential (CPP), which defined the proportion of chickens that could be utilized by a household, averaged 50%. Chicken production efficiency was about 15% of the CPP in Zimbabwe.

Lower production levels for Diet 1 compared to commercial layer diet probably was due to lower content of protein (14.9%) for Diet 1 and minimum 16% for a commercial layer diet. This was different from Sonaiya (1993), who reported that 50% replacement of a commercial grower ration using a simple ration formulated with palm oil sludge had no significant effect on the growth rate, intake and feed efficiency of commercial cockerels raised in cages. The difference may be because birds were raised in cages in Sonaiya's trail. However, this result was agreed with Hassan et al. (2000), who evaluated the egg production of six local hens aged from 20-40 weeks in relation to dietary protein levels and found that hens fed on high protein diet (17.50%) had higher hen-day egg production, egg weight, egg mass and feed conversion compared to those fed on low protein ration (13.67%). However, using local available feed could reduce the cost and increase profitability for smallholders. Proper processing feed ingredients and mixing with minerals and vitamins may improve the feed efficiency, hence production of hens.

11.3.5 References

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Solomon Island trial results for diet 2

Date	Treatment	Body weight (kg)	Weight gain (g/week)	No. of eggs	Egg weight (g)	Total egg wt	Total Feed Intake (g)	Egg (%)	Feed (g)/12eggs	FCE (%)
Week 0	Control	1554.7								
	Diet 2	1615.7								
	P	0.537								
	SEM	44.663								
Week 1	Control	1618.5	63.7	26.7	44.2	1167.7	756.0	47.8	3661.5	15.8
	Diet 2	1782.7	-83.0	13.7	44.6	619.7	4110.5	24.5	4080.3	15.5
	P	0.614	0.011	0.033	0.913	0.036	0.000	0.033	0.723	0.955
	SEM	146.153	33.472	3.283	1.560	140.039	670.787	5.862	528.705	2.161
Week 2	Control	1625.2	6.7	32.0	48.7	1554.7	7156.5	57.1	2703.2	21.6
	Diet 2	1519.2	-13.5	9.5	44.1	176.5	5299.7	17.0	21256.7	3.2
	P	0.143	0.229	0.010	0.006	0.000	0.012	0.010	0.208	0.000
	SEM	35.350	7.984	5.091	1.008	268.967	425.242	9.091	7031.524	3.516
Week 3	Control	1606.7	-18.5	28.5	49.8	1418.5	7740.7	50.9	3261.3	18.4
	Diet 2	1508.0	-11.2	6.5	43.7	296.0	5067.0	11.6	21269.6	5.5
	P	0.165	0.746	0.000	0.036	0.000	0.001	0.000	0.162	0.001
	SEM	34.425	9.999	4.383	1.561	221.473	550.405	7.828	6241.845	2.654
Week 4	Control	1603.7	-3.0	28.7	50.1	1436.7	7274.7	51.3	3115.9	19.8
	Diet 2	1479.2	-28.7	11.5	48.5	528.5	4999.7	20.5	7869.3	10.3
	P	0.069	0.077	0.010	0.006	0.006	0.007	0.010	0.199	0.039
	SEM	35.123	7.415	3.898	1.011	199.367	505.590	6.961	1769.925	2.440
Week 5	Control	1581.7	-22.0	23.2	50.3	1169.7	5498.0	41.5	2860.5	21.6
	Diet 2	1510.7	31.5	6.7	44.9	311.5	5290.2	12.0	12059.1	6.1
	P	0.126	0.169	0.000	0.057	0.000	0.690	0.000	0.050	0.002
	SEM	22.857	18.794	3.251	1.464	169.453	233.228	5.806	2456.4	3.203
Week 6	Control	1575.2	-6.5	28.2	50.4	1413.7	6470.7	50.4	2909.7	21.5
	Diet 2	1535.5	24.7	5.5	47.0	252.5	6702.0	9.8	20654.2	3.9

	P	0.422	0.118	0.003	0.154	0.002	0.688	0.003	0.062	0.000
	SEM	22.634	9.889	4.805	1.157	241.221	257.578	8.580	4914.5	3.498
Week 7	Control	1568.0	-7.2	19.2	49.7	946.7	4741.2	34.4	2994.4	20.2
	Diet 2	1529.2	-6.2	8.7	44.7	395.0	5739.5	15.6	10378.2	6.8
	P	0.199	0.974	0.016	0.063	0.006	0.086	0.016	0.053	0.001
	SEM	14.415	13.542	2.464	1.380	121.100	294.076	4.400	1994.633	2.734
Week 8	Control	1601.5	33.5	21.0	49.9	1042.7	5071.2	37.5	3155.0	20.0
	Diet 2	1527.2	-2.0	14.0	46.8	657.2	5743.7	25.0	7277.7	11.2
	P	0.120	0.171	0.303	0.012	0.238	0.232	0.303	0.191	0.083
	SEM	23.587	12.520	3.168	0.719	154.378	266.192	5.657	1511.038	2.581
Week 9	Control	1585.2	-16.2	21.0	49.2	1033.2	5275.5	37.5	3143.6	19.6
	Diet 2	1445.5	-81.7	12.7	47.7	611.5	5870.0	22.8	6351.4	10.4
	P	0.039	0.204	0.093	0.079	0.085	0.243	0.093	0.045	0.044
	SEM	36.073	24.599	2.467	0.438	123.863	240.599	4.406	844.871	2.428

Solomon Island trial results for diet 3

Table 1. The performance of hens on Diet 3 and a commercial layer diet.

Date	Treatment	No. of eggs	Egg weight (g)	Feed intake (g/d/b)	Body weight/b (g)	Wt gain g/d/d	Egg (%)	Feed (g)/12eggs	Egg wt/feed intake (%)
Week 1	Diet 3	13.7	45.6	71.4	1580.0	-1.54	24.5	3599.8	21.9
	Control	18.7	46.6	95.8	1627.0	-0.04	33.5	3672.8	16.5
	P	0.117	0.655	0.002	0.609	0.081	0.117	0.930	0.010
	SEM	1.578	0.976	5.09	41.3	0.436	2.818	369.765	1.222
Week 2	Diet 3	6.0	46.5	81.1	1592.7	0.21	10.7	10805.1	19.6
	Control	23.2	47.2	94.5	1657.0	0.54	41.5	2870.0	16.9
	P	0.002	0.774	0.019	0.474	0.421	0.020	0.043	0.065
	SEM	3.595	1.016	3.19	40.84	0.183	6.42	2072.96	0.747
Week 3	Diet 3	10.2	47.3	84.7	1615.5	0.41	18.3	7077.5	19.1
	Control	23.5	46.5	95.7	1672.0	0.27	42.0	2765.5	16.5
	P	0.004	0.600	0.059	0.489	0.850	0.004	0.108	0.052
	SEM	2.84	0.734	3.02	37.10	0.326	5.067	1335.57	0.694
Week 4	Diet 3	14.5	46.2	70.5	1574.2	-0.74	25.9	3858.0	22.3
	Control	16.5	48.8	94.6	1656.0	-0.29	29.5	4038.2	17.5
	P	0.560	0.068	0.001	0.377	0.667	0.560	0.889	0.001
	SEM	1.55	0.72	4.86	42.61	0.470	2.762	576.54	0.968
Week 5	Diet 3	6.0	43.8	74.3	1529.5	-0.80	10.7	12274.0	20.1
	Control	16.7	49.2	95.3	1681.2	0.45	29.9	4128.0	17.5
	P	0.017	0.010	0.001	0.223	0.287	0.017	0.137	0.017
	SEM	2.54	1.23	4.26	59.08	0.55	4.54	2685.54	0.60
Week 6	Diet 3	7.7	46.4	79.2	1528.5	-0.018	13.8	7695.6	19.8
	Control	17.5	47.9	97.3	1681.5	0.004	31.2	3790.9	16.7
	P	0.003	0.614	0.002	0.212	0.956	0.003	0.032	0.008
	SEM	2.06	1.32	3.77	58.33	0.180	3.68	984.58	0.70
Week 7	Diet 3	9.5	49.4	70.9	1485.2	-0.77	17.0	5492.9	23.8
	Control	17.5	47.9	98.0	1704.7	0.41	31.2	3931.1	16.6
	P	0.028	0.566	0.000	0.077	0.096	0.028	0.180	0.003
	SEM	1.98	1.17	5.42	63.17	0.36	3.54	560.32	1.53
Week 8	Diet 3	8.2	45.2	70.8	1474.2	-0.20	14.7	6764.2	21.9
	Control	17.2	48.0	96.1	1645.0	-1.07	30.8	4072.0	17.0
	P	0.049	0.271	0.002	0.342	0.536	0.049	0.151	0.021
	SEM	2.40	1.16	5.26	83.15	0.64	4.28	912.08	1.19
Week 9	Diet 3	11.0	47.0	60.3	1432.7	-0.74	19.6	4739.5	27.1
	Control	19.0	49.1	91.8	1629.7	-0.27	33.9	3434.0	18.3
	P	0.108	0.238	0.009	0.289	0.321	0.108	0.41	0.011
	SEM	2.48	0.83	7.09	86.74	0.22	4.43	732.36	2.02

Solomon Island trial results for diet 4

Date	Treatment	Body weight (kg)	Feed Intake (g)	Egg No.	Egg weight (g)	Egg (%)	Feed (g)/12eggs
Week 1	Control	1729.6	82.8	19.0	50.5	30.2	3638.8
	Diet 1	1656.4	85.5	8.7	51.3	13.7	8616.3
	P	0.445	0.463	0.055	0.698	0.055	0.053
	SEM	43.682	1.719	2.802	0.853	4.447	1344.4
Week 2	Control	1773.7	90.4	11.5	48.3	18.2	9582.5
	Diet 1	1540.1	84.3	8.7	49.7	13.7	22457.3
	P	0.039	0.549	0.611	0.657	0.611	0.439
	SEM	60.392	4.644	2.427	1.341	3.853	7390.5
Week 3	Control	1786.4	64.2	23.2			
	Diet 1	1462.8	61.3	0.3			
	P	0.009	0.647	0.001			
	SEM	72.844	2.842	4.815			
Week 4	Control	1799.4	83.0	30.0			
	Diet 1	1391.6	83.3	0			
	P	0.011	0.959	0.000			
	SEM	93.205	2.202	6.250			
Week 5	Control	1779.4	76.9	25.2			
	Diet 1	1333.2	89.2	0			
	P	0.002	0.051	0.000			
	SEM	92.529	3.292	5.182			
Week 6	Control	1664.8	80.7	18.7			
	Diet 1	1266.9	81.2	0			
	P	0.001	0.921	0.012			
	SEM	81.577	2.313	4.374			
Week 7	Control	1591.1	81.7	13.7			
	Diet 1	1229.9	83.7	0			
	P	0.011	0.747	0.072			
	SEM	82.197	3.409	3.894			
Week 8	Control	1605.2	73.1	25.2			
	Diet 1	1136.6	80.8	0.7			
	P	0.001	0.223	0.000			
	SEM	96.396	2.991	5.055			
Week 9	Control	1600.7	77.2	19.0			
	Diet 1	1224.7	80.9	0			
	P	0.021	0.647	0.025			
	SEM	90.341	3.579	4.693			

11.4 Appendix 4: Performance of meat birds grazing on fresh herbs; rosemary (Rosemarinus officinalis), thyme (Thymus vulgaris), fennel (Foeniculum vulgare) and sage (Salvia officinalis)

11.4.1 Introduction

There is growing interest in feeding herbs to poultry and other livestock as a substitute for antibiotics (Varley, 2005). However there is little information available on whether free range meat chickens will forage on herbs and if the fibre and mineral component in herbs can effect bird growth and gut structure as found by Hetland et al. 2004 and Tabook et al. 2006. It is well known that herbs are commonly used for human medicine in Asia, (particularly in China) and have the potential to treat cancer (Singletary and Rokusek, 1997; Singletary et al., 1996). Evidence is also available indicating thyme is effective at inhibiting bacteria and also contains flavanoid and phenolic compounds which are antioxidants (http://www.theolivebranch.com/herbs/thyme.htm). Mwale et al. (2005) reported that smallholder farmers in Zimbabwe use herbal plants Aloe vera and Aloe spicata extensively to manage chicken health.

Two trials were undertaken to determine if meat chickens would consume fresh herbs and whether herbs have any influence on production, quality of the meat and gut characteristics.

11.4.2 Materials and methods

Birds, herbs and treatments: In the first experiment at Roseworthy Campus in South Australia using the herbs rosemary and thyme 120 chickens (Cobb meat chicken strain) were housed in an eco-shelter (3m x 3m) at 17 days of age. In the second experiment with sage and fennel birds were housed at 23 days of age. In each trial chickens were randomly allocated into 3 treatments (2 herbs + 1 control) each comprising 2 replicates of 20 birds. Control birds were fed a commercial grower diet (control). The treatment birds were provided the control diet but also allowed to graze on the rosemary and thyme in experiment 1 and sage or fennel in experiment 2. Three pots of the each herb were placed in each pen and grazed by birds from 9:00am to 5:00pm for 4 weeks.

Measurements: Body weight, feed intake and herb intake were measured weekly and at the end of each experiment, 4 birds from each treatment were euthanased with 0.5 ml of pentobarbitone injected into the brachial vein. The crop content and tissue weight were determined. Proximate and mineral content in leaf and stem of herbs were also determined. For the rosemary vs. thyme vs control experiment a taste test was undertaken with the breast meat of birds after it had been roasted in an oven bag without any addition of flavours or spices. 29 staff from the Livestock Systems Alliance at Roseworthy Campus were asked to comment whether the flavour, colour and texture of roast chicken they consumed was very poor, poor, average, good or excellent. The flavour and quality of meat was evaluated using a scoring system (1=very poor; 2=poor; 3=average; 4=good and 5=excellent).

Statistics: The treatment effects were analysed with ANOVA in Systat software (Wilkinson, 1996). Bonferroni's post hoc was used to separate means only if significant main effects were detected by analysis of variance. Bonferroni's post hoc test is a multiple comparison test based on Student's t statistic and adjusts the observed significance level when multiple comparisons are made.

11.4.3 Results

The rosemary and thyme leaves contained more nutrient and less crude protein compared to the stems. Both sage leaf and stalk had higher gross energy and Fe than fennel leaf and stalk. There are no other reports in the literature comparing nutrient values of these herbs. There was no significant difference in bird performance between treatments (Table

1). FCR was numerically lower for the rosemary and the thyme group compared to the control group, but birds grazing on fennel had poorer FCR compared to the control. Birds on the herb treatments ingested 15.9g/bird of fresh rosemary, 16.0g/bird of thyme, 8.6g/bird of fennel and 5.0g/bird of sage.

Table 1. The production performance of birds foraging on Rosemary and Thyme (experiment 1) and Fennel and Sage (experiment 2)

Treatment	Bird wt (start g/bird)	Daily gain (g/bird)	Feed intake (g/bird/day)	FCRa (g feed/g wt)	Estimated herb intake (g)	FCR-Herbb (g feed + herb/g wt)
Experiment 1						
Control	376.4	68.2	156.6	2.3	-	2.3
Rosemary	400.7	68.5	134.8	2.0	15.9	2.2
Thyme	388.1	70.7	140.6	2.0	16.0	2.3
P-value	-	0.97	0.54	0.15	0.98	0.88
SEM	-	4.06	8.04	0.08	2.14	0.07
Experiment 2						
Control	700	91.9	185.9	2.08	-	-
Fennel	720	70.2	157.2	2.23	8.6	2.35
Sage	750	81.9	157.2	2.03	5.0	2.10
P-value	-	0.272	0.145	0.489	0.243	0.135
SEM	-	5.402	5.887	0.069	1.521	0.083

FCRa=feed conversion rate calculated without including herb intake; FCRb=feed conversion rate calculated with inclusion of herb intake.

There were no significant differences in crop weight, crop tissue weight and crop contents between rosemary and thyme treatments (Table 2). Both dry and wet crop content were heavier for herb treatments compared to the control. Crop empty weight was also heavier for herb treatments than the control. Birds grazing on fennel had heavier ($P<0.05$) dried crop tissue weight than birds on the control diet. Birds grazing on sage also had a heaver dried crop tissue than the birds on control diet, but this was not significantly ($P>0.05$) different.

Table 2. The crop content (CC) weight (CCWt), crop tissue (CT) weight (CTWt) of birds

		Experiment 1			Experiment 2	
	Control	Rosemary	Thyme	Control	Fennel	Sage
CCwt (Wet)	12.7	48.4	67.1	28.6	99.7	115.4
CCwt (Dry)	4.3	20.7	20.9	12.1	48.1	42.8
CC (Moisture %)	8.5	27.6	46.2	16.5	51.6	72.6
CTWt. (Full)	22.4	59.7	76.1	36.0	113.5	130.3
CTWt. (Empty)a	8.0	8.0	20.0	6.9b	14.7a	14.8a
CTWt. (Dry)	2.3	2.4	4.2	1.7b	3.5a	3.4ab
CT (Moisture %)	5.7	5.7	15.8	5.1b	11.1a	11.4a
CC Herb	0	0.10	0.03	0	0.1	0
CC Feed	4.1	20.1	20.4	12.0	47.6	42.7
CC Otherb	0.10	0.12	0.12	0.1	0.5	0.5

a Value with different letter in the same row and the fennel and sage experiment was significant difference ($P<0.05$).
b CC other included sawdust (litter), potting soil and feathers.

There was a significant difference in scores for meat flavour between the control (3.48) and thyme (2.86) treatment (Table 3) but no significant difference between control (3.48)

and rosemary (3.41) treatments. There were no significant differences in colour and texture between the treatments.

Table 3. Flavour, colour and texture of meat from birds grazing on Rosemary and Thyme compared to a control diet

	Control	Rosemary	Thyme	P value	SEM
Flavour	3.48	3.41	2.86	0.003	0.137
Colour	3.59	3.38	3.38	0.446	0.132
Texture	3.17	3.28	2.79	0.074	0.155

Note: score system. 1=very poor; 2=poor; 3=average; 4=good and 5=excellent.

11.4.4 Discussion

Supplementing fresh herbs did not significantly affect bird performance in this experiment apart from a lower FCR for the fennel treatment. Chen et al. (2002 unpublished data) also found there were no significant effects of herb treatments on growth performance of birds. However, Khajarern et al. (2004) reported that feeding A. paniculata powder to meat chickens increased growth rate compared to an antibiotic growth promoter. Guo et al. (2004) also reported that inclusion of a Chinese herbal medicine in a chicken meat diet increased body weight gain at 7 to 21 d of age but not at 21 to 28 d of age. However, herbs had no significant effects on either liver or intestinal tract weights. On the other hand Al-Ankari et al. (2004), found that including 150 g/kg habek into a chicken meat diet resulted in a significant improvement in the body weight, daily gain, feed intake and food conversion ratio. The results from our trial support the findings that herbs do not improve growth. However the dry crop tissue weight of birds grazing on thyme was heavier than the birds on the control and the rosemary treatment. The weight of crop tissue and crop content (wet and dry) were also heavier for fennel and sage treatments. This could indicate that herbs enhanced the development of the crop probably due the fibre content (Tabook et al. 2006). This may slow down the feed passage rate through the crop and enhance digestibility (Hetland et al. 2004).

There would be a common perception that birds grazing on herbs would produce meat with a better taste. However the results showed that meat from the rosemary treatment was similar to the control while flavour, colour and texture of meat from thyme treatment were poorer than the control birds. These finding support recent work that organic meat is not as tastier as meat from birds grown under commercial conditions (http://www.worldpoultry.net/news/id2205-51210/organic_chickens_have_less_flavour.html).

In conclusion the trials have shown that meat birds will forage on herbs resulting in changes in weight to segments of the alimentary tract which may influence transit time and digestibility of feed in the gut. However the health aspects of foraging on herbs needs further investigation particular the effect on the profile of gut bacteria. It would appear that fresh herbs could be included in a free-range pasture for meat birds to graze without impacting on performance.

11.4.5 References

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11.4.6 Acknowledgement

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11.5 Appendix 5: The diet mixing fact sheets for village farmers

Pig and Poultry Production Institute

Diet Mixing Fact Sheet

SARDI R&D RESEARCH AND DEVELOPMENT

Collect all ingredients

Prepare ingredients peeling, mashing, chopping, grating

Cook (if required)

Weigh Ingredients

Mix Ingredients

Consistency

Final Diet

Feed to chickens

Pig and Poultry Production Institute

Village Poultry Diet 1

SARDI RESEARCH AND DEVELOPMENT

Ingredients For 1kg Mix	Amounts
 Corn (or Sorghum)	 450 grams Corn (or Sorghum)
 Paw Paw	 50 grams Paw Paw
 Mung Bean	 300 grams Mung Beans
 Fish Meal	 50 grams Fish Meal
 Cassava	 63 grams Cassava
 Betel Nut Lime	 80 grams Betel Nut Lime

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Village Poultry Diet 1

SARDI R&D SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Ingredients	Amounts
 Salt	 3 grams Salt

If available it is good to add

 Pre-mix (vitamins & minerals)	 2.5 grams Pre-mix
 Lysine	 0.9 grams Lysine
 Methionine	 0.6 grams Methionine

If premix, lysine & methionine not available let out chickens to free range to eat grass and insects every afternoon for 1-2 hours to obtain vitamins and minerals

Diet 4 - Mix for 10 chickens for 1 day

Ingredients For 1kg Mix	Amounts
 Leucaena Leaf Meal Fresh	 50 grams Leucaena
 Sweet Potato	 400 grams Sweet Potato
 Sweet Potato Vine fresh	 20 grams Sweet Potato Vine
 Banana	 200 grams Banana
 Chilli	 20 grams Chilli
 Clover	 100 grams Clover
 Termites	60 grams Termites
 Worms/maggots	 100 grams Worms/maggots
 Shell	 50 grams Shell (crushed)
	**Let out chickens to free range to eat grass and insects every afternoon for 1-2 hours to obtain vitamins and minerals**