FEED SELECTION AND GROWTH PERFORMANCE OF LOCAL CHICKENS OFFERED DIFFERENT CARBOHYDRATE SOURCES IN FRESH AND DRIED FORM SUPPLEMENTED WITH PROTEIN-RICH FORAGES

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Msc. Thesis

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Dedication

To my parents, Kong Hun and In Chhen

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Abbreviations

BW	Body weight
Ca	Calcium
CP	Crude protein
CRD	Completely Randomized Design
Cu	Copper
DM	Dry matter
Fe	Iron
K	Potasium
Mg	Magnesium
Mn	Manganese
N	Nitrogen
Na	Sodium
P	Phosphorus
Zn	Zinc

1. Introduction

Poultry production in most developing countries is based mainly on the scavenging system with birds reared in backyards. About 90-95 % of the rural households raise some indigenous chickens, ranging from 5-50 birds per household (Chantalakhana and Skunmun 2002, CelAgrid 2006). Saleque (1996) reported that scavenging village chickens play a significant role in poverty alleviation in developing countries. However, to perform well birds need feeds that provide the necessary nutrients for body functions, including growth, egg and meat production. This is a requirement that the free-range production system does not meet adequately. To attain a balanced diet, it is recommended that scavenging chickens should be supplemented with protein feeds, especially in the dry season. Green forages are locally available resources which can be good and cheap feeds, and contain some protein and vitamins. Examples of green forages found in the humid tropics include duckweed, water spinach, taro leaf, cassava leaf, sweet potato leaf etc. Birds also need carbohydrates to supply energy for scavenging and production (Ondwasy et al 2006). Several authors, including Tadelle and Ogle (1996), Rodriguez and Preston (1997), Kingori (2004) and Okitoi et al (2006) reported that supplementing scavenging chickens with different feeds can have positive effects. Henuk and Dingle (2002) in a review of diet selection by poultry reported strong evidence that when domestic birds were offered different feedstuffs they had the ability to choose a diet that provided them with the nutrients necessary for maintenance, growth and production.

In the uplands and some lowland areas of Cambodia and Laos, many types of crop are grown for income by smallholders, such as cassava, sweet potato, banana and various grain crops. These are also sources of low cost carbohydrates for humans and animals. The price at harvesting time is often very low. In this case, the farmers can decide to use some for feeding their scavenging chickens. Feeding carbohydrates to the chickens in the fresh form is the easiest method, but some anti-nutritional factors are present in the fresh form of several carbohydrate rich crops, and they need be treated to reduce them to a level which is not toxic for the birds. Cassava roots, sweet potato tubers and green banana fruit contain different anti-nutritional factors [eg: trypsin inhibitors in sweet potato tubers (Collins 1995 and Bradbury et al 1985), HCN in cassava roots (O'Hair 1995) and tannins and oxalate in banana fruit (Onibon et al 2007)] which may affect the intake and digestibility. Therefore, the studies reported in this thesis will provide information as to which green forages and carbohydrate feeds chickens prefer when given free choice, and which carbohydrate feeds can be used fresh and which should be processed before they can be used as poultry feed.

2. Objectives

- To compare the selection of different green forages and carbohydrate feeds by local chickens
- To compare the feed intake and growth performance of chickens fed on different sources of carbohydrate and green forage
- To evaluate the effects of fresh and processed carbohydrate feeds on local chickens

3. General discussion

3.1 Small scale poultry production in developing countries

Poverty, hunger and malnutrition are common among smallholder families in developing countries. Most of the poor people rely on agricultural work to support their families. Evaluation reports from a number of integrated development projects in developing countries indicated that scavenging village chickens play a significant role in poverty alleviation and in enhancing gender equity among the disadvantaged communities (Saleque 1996). Alders et al (2009a) also reported that village chickens also play an important role in poverty alleviation and HIV/AIDS mitigation. Raising backyard chickens in villages continues to provide a fairly substantial portion of the domestic meat consumption, although commercial poultry production has become a successful and highly competitive enterprise. About 90-95 % of the rural households in developing countries raise some indigenous chickens, ranging from 5-50 birds per household, and these offer a short term or current savings account for daily petite cash needs (Chantalakhana and Skunmun 2002, CelAgrid 2006). Chicken production becomes part of the whole farming system. The type of chickens kept and managed is highly influenced by various biological, cultural, social and economic factors. In most developing countries chickens scavenge within the village boundaries. Their nourishment depends on the feed available in the village, their health and the local disease situation. Village chicken improvement programs also have the potential to contribute to each of the development goals and to improve the situation of the most vulnerable families in developing countries (Ahlers et al 2009b).

In Cambodia, the village chicken has an important role in supplying meat for provincial town and city markets and the meat is preferred by local food processors such as local restaurants, and street vendors of grilled and roasted chicken. According to AsiaDHRRA (2008), 11 tonnes of chicken meat per day are supplied and consumed in Phnom Penh City. About 80% of this is from free range chickens raised by smallholder farmers and 20 % from commercial entrepreneurs who use relatively advanced technology (housing and management) and concentrate feed. This production is considered as a part of small farmers' income generation, and does not require as much time, investment and labour as other livestock species. The farmers just supply some locally available feeds, such as paddy rice, rice bran, broken rice, termites, water spinach and kitchen waste after or before freeing their chickens to scavenge (CelAgrid 2006). Besides own household consumption, the small farmer is able to supply around 100 chickens on average 4 times per year (AsiaDHRRA 2008).

3.2 Feed preferences and the cafeteria system for poultry

The method of cafeteria or free-choice feeding of poultry offered a selection of different feed ingredients has been recognized for a long time (Winter and Funk 1951) and was a common practice before knowledge regarding the formulation of complete diets had reached its present high standard. This method gives the birds the opportunity to select nutrients, particularly protein and energy, according to their physiological demands (Emmans 1978). Relating to expenditure, the use of this feeding system may reduce feed processing costs, such as for grinding, mixing and many of the handling procedures associated with mash production, which are in fact unnecessary (Kiiskinen 1987; Tauson et al 1991). An additional advantage is that each bird is able to select the optimum amount of each of the components to satisfy its own nutrient requirements and the consequent increase in efficiency would represent additional savings (Emmans 1979; Hearn 1979; Belyavin 1994). Pousga et al (2005) reported that free choice feeding is an infinitely more natural and delicate system of feeding. Each bird can accurately select the balance of nutrients to meet its particular physiological requirement.

As long as the hens are given the opportunity to make clear and easy nutritional choices, they will be healthy and productive. Okitoi et al (2009) also reported that scavenging chickens with access to a cafeteria feeding system consumed diverse scavengeable food resources, that can be grouped into animal, vegetable, sand and grit, and the components of animal origin contributed essential amino acids (eg: lysine, tryptophan, methionine and cystine) to the diet. Those of vegetable origin contributed more energy, and while feeding on a range of animal and vegetable components, the appetite for essential amino acids seems to drive scavenging chicken preferences**.** Farmers may prefer this system because they could have access to cheap cereal grains and suitable protein concentrate sources to mix on farm (Tauson et al 1991) as well as locally available green forages, and thus have no need of a grinding machine.

3.3 Green forages for local chickens

Green forages have a great potential and role in the nutrition of all kinds of animals raised by small farmers in rural areas, especially for ruminants. The products (eg. duckweed, water spinach) and by-products (eg. cassava leaf, taro leaf and sweet potato leaf) are locally valuable and have low cost for farmers to use as feeds for animals. Moreover, they are also a good source of nutrients (Table 1 and 2) including protein, vitamins and minerals. Village chickens prefer to consume them during scavenging, and Okitoi et al (2009) reported that green vegetables and grass are often found in the crop contents of these chickens.

3.3.1 Duckweed (Lemna spp)

Duckweed is a group of small floating aquatic plants found in natural ponds, lakes and flooded rice fields. It can be grown to recycle nutrients from waste water and it provides a good source of proteins and can be utilized for the production of some products such as animal feed and fuel ethanol (Cheng and Stomp 2009). This plant grows rapidly and gives high yields with high protein content, low fiber content and high mineral content. Moreover, it is non-toxic and is only attacked by a few known pests. The annual dry matter (DM) yield of duckweed is 10-30 t/ha (Huque 1998).

Chemical composition and utilization of duckweed in chicken diets

Duckweed has high nutritional value and high productivity (Hillman and Culley 1978) but the crude protein content of duckweeds depends mainly on the N content of the water upon which they grow and there are also some variations in amino acid content of duckweed proteins. It can be collected and used as poultry feed. Moreover, duckweed has less cell wall materials than other aquatic plants. The crude protein content of duckweed can be as high as 39.3 % in dry basis (Bui Xuan Men et al 1996) and is rich in essential amino acids. So, duckweed is a potentially useful protein source for poultry. Recent studies have demonstrated that replacing a protein source with duckweed meal in conventional diets for young broiler chickens retarded chicken growth as its inclusion levels increased (Haustein et al 1992b, 1994), whereas layers still produced efficiently (Haustein et al 1988) and older broiler birds had excellent growth characteristics when fed relatively high levels of duckweed meal. Skillicorn et al (1993) reported that duckweed meal can be fed to layers at up to 40% of total feed with satisfactory results. This indicates that duckweed of known chemical composition can be used in least-cost ration formulations for both poultry meat and egg production. However, the lower growth performance of local chickens fed on duckweed is not an important issue for smallholder farmers, as their aim is not the maximization of growth but on the optimum economic return.

3.3.2 Water spinach (Ipomoea aquatica)

Water spinach is the most common plant species grown in wetlands in terms of aquatic vegetable production. This production requires relatively easy growing techniques with lower labour costs compared to other cultivated plants. In Cambodia, besides growing on inland waterways, this aquatic plant is commonly cultivated all year round in the surrounding wetlands or in the lakes around Phnom Penh to treat urban domestic wastewater. It is a primary source of nutrients (Khov Kuong et al 2007) because it has high potential to convert efficiently the nitrogen in the effluent into edible biomass with high protein content (Kean Sophea and Preston 2001). Water spinach is usually consumed by both people and animals. It is also readily available, growing naturally in ponds, flooded fields and lagoons, and is more abundant in the rainy season. There are two types of water spinach, aquatic and inland varieties, commonly cultivated by farmers. Stems are commonly used as planting materials for the aquatic variety while commercial seeds as used for the inland variety. When water is not a constraint, the aquatic water spinach has the capacity to produce foliage for longer periods.

Chemical composition and utilization of water spinach in chicken diets

Water spinach is a good source of protein and can be used as feed for all kinds of animal and for humans. The foliage contains protein in the range of 23.6 % in the dry season and 27.6 % in the wet season (Nguyen Nhuy Xuan Dung 1996), and is also a good source of trace minerals (mg/kg): Zn, 5.03; Mn, 22.2; Cu, 1.37 and Fe, 75.3 (NIAH, 1995) and is rich in vitamin A and C. The nutrients concentrate mainly in the leaves. Umar et al (2007) reported that the mineral element contents in the leaves were high, in particular the concentration of K and Fe. Also the leaves contain moderate concentrations of Na, Ca, Mg and P, with low Cu, Mn and Zn contents.

In rural regions, water spinach is commonly used by smallholders to feed their scavenging poultry, as a supplement mixed with rice bran. Using water spinach for local chickens indicates that it is also the preferred foliage to provide protein and vitamins for growing chickens (Experiment 1). Nguyen Thi Thuy and Ogle (2004) reported that when chickens had access to green feeds such as water spinach or duckweed, the color of the skin and the egg yolk were improved which makes the products more attractive to the customers.

3.3.3 Taro leaf (Colocasia esculenta)

In Cambodia, taro can be found in most parts of the country, particularly along the Great Lake and Mekong River. Farmers grow taro for its edible corms (root) and vegetable stems. The yield of the corms and foliage is high. Taro leaf which is not used as human feed can be a potential protein source for animals according to the good nutritional quality of the leaves. FAO (1993) reported that taro leaf (in DM basis) has 25.0% crude protein, 12.1% crude fiber, 1.74% Ca and 0.58% P, and thus can be a good alternative feed for village chickens.

Chemical composition and utilization of taro leaf in chicken diets

The taro leaf is rich in protein, and contains about 23% crude protein on a dry weight basis. It is also a rich source of calcium, phosphorus, iron, vitamin C, thiamine, riboflavin and niacin, which are important constituents of human and animal diets. The fresh taro lamina (leaf) has about 20% dry matter, while the fresh petiole has only about 6% dry matter (Onwueme 1999). According to Rodriguez et al (2006), fresh leaves of *Xanthosoma sagittifolium* (a member of the taro family) contain 24.8 % of crude protein. Leterme et al (2005) also reported that *Xanthosoma* leaf had a high amino acid content and a good balance of amino acids.

In rural areas, people normally use taro leaves for food by boiling or preparing in various ways and mixing with other condiments. In the coastal zone of Cambodia, taro leaves are used by smallholders as extra feed for their scavenging pigs after cooking (Kong Saroeun et al 2007). Until now, there seems to be no research on the use of taro leaf for poultry, and a recent study demonstrated that using fresh chopped taro leaf for chickens had a negative effect on the intake of the birds (Experiment 1) because they did not eat the leaves, probably due to the high calcium oxalate content in the fresh leaf.

Anti-nutritional factors in taro leaf

The leaves of taro are rich in protein but contain calcium oxalate, which appears to be a limiting factor for its use as animal feed (Tiep et al 2006). Savage and Dubois (2006) reported that the soluble oxalate content of the raw leaves was 236 mg oxalate/100 g fresh matter. The soluble oxalate content can be reduced by soaking or cooking. Soaking for 18 h can reduce the soluble oxalate content by 26%. During the soaking treatment the insoluble oxalate (calcium oxalate) content of the leaves remained constant (mean 171 mg oxalate/100 g wet matter). Boiling the taro leaves resulted in a 36% loss of soluble oxalates, while the soluble oxalate content of baked tissue was very similar to the raw tissue. The mean insoluble oxalate content of the raw, boiled and baked tissue was 226 mg oxalate/100 g fresh matter. Overall, boiling the taro leaves was shown to be an effective way of reducing the soluble oxalate content of the tissue. Besides, the calcium oxalate content in taro leaf can also be reduced by sun-drying and ensiling, and Pheng Buntha (2008) reported that these processes can reduce calcium oxalate from 3.08 % in DM in the fresh leaf to 1.1 % after sun-drying and 0.11 % after ensiling.

Table 1 : Composition of green forages (% of DM)

Chemical composition	**Duckweed**[a]	**Water spinach**[b]	**Taro leaf**[c]
Dry matter, %	4.93	7.02	8.2
Crude protein	39.3	35.9	25
Ether extract	6.19	5.64	-
NFE	10.7	-	-
Fibre	16.6	7.51	12.1
Ash	17.4	14.2	-
Ca	1.00	1.03	1.74
P	1.52	0.83	0.58

Source: [a]Bui Xuan Men et al 1996, [c]Nguyen Thi Thuy and Ogle 2005, [c]FAO 1993

Table 2: Amino acid composition of the protein of green forages

Amino acid	**Duckweed**[a] (% of protein)	**Water spinach**[b] (% of feed)	**Taro leaf**[c] (% of feed)
Leucine	7.15	-	0.392
Isoleucine	3.87	-	0.260
Valine	4.96	-	0.256
Methionine	0.83	0.07	0.079
Tryptophan	-	0.04	0.048
Phenylalanine	4.45	-	0.195
Tyrosine	2.91	0.14	0.178
Lysine	4.13	0.14	0.246
Threonine	3.2	-	0.167
Histidine	1.89	-	0.114
Arginine	4.29	-	0.220
Serine	2.61	-	-
Proline	2.93	-	-
Glycine	3.79	-	-
Glutamic acid	7.60	-	-
Cystine	-	-	0.064
Aspatic acid	7.12	-	-

Source:[a]*Rusoff et al 1980,* [b]*NIAH 1979,* [c]*Jai Dee Marketing 2010*

3.4 Carbohydrate feeds for local chickens

Energy is required in varying amounts for all metabolic purposes, so a deficiency of energy affects most aspects of the productive performance of poultry. If the available energy concentration of the diet is changed, birds maintain constant energy intakes by changing their feed intakes (Rose 1997). Therefore, energy is required for chickens for supporting activities during scavenging and productive performance. Locally available resources are useful as energy feeds when they are abundant and low in price.

3.4.1 Cassava root (Manihot esculenta Crantz)

In developing countries, especially in the rural areas, farmers grow cassava as a subsistence crop and use it as a staple food and as livestock feed, as well as a source of cash income. However, cassava yields might be low in traditional systems because of a shortage of high yielding varieties and the use of inappropriate agronomic techniques. In Cambodia, the production, yield and harvested areas of cassava are low compared to the other Asian countries. Generally the harvesting period of cassava is 6-8 months after planting, and without fertilization yields of cassava range from 4-6 tons/ha (Khieu Borin and Frankow-Lindberg 2005). Normally, the crop has a high yield potential and can withstand poor soils and drought, and yields 25 to 60 tons/ha, depending on variety and cultivation practice (FAO 2008).

Chemical composition and utilization of cassava root in chicken diets

Cassava root is rich in energy with little ascorbic acid, but is low in fat, minerals, other vitamins and especially proteins. The carbohydrate of cassava is an excellent digestible starch. In cassava root, amino acids are not balanced. Several sulfur-containing amino acids are limiting and excess arginine contributes to the imbalance (Silvestre & Arraudeau 1983). Normally, whole roots or fresh cassava roots are fed to cattle and pigs, either raw or in the boiled form. However, feeding fresh roots may cause cyanide toxicity, depending on the cyanide content in the roots (Mathur et al 1969). For storage, as well as when feeding to poultry, it is advisable to dry it and bring down the moisture level to about 10%. Cassava has been used as animal feed in the fresh form or dried. In the semitropical zone, whole or peeled cassava is often offered to sheep, goats and pigs. In small scale pig or poultry production, it is used fresh or boiled and mixed with other products, such as maize, sorghum and broken rice (Silvestre & Arraudeau 1983).

Anti-nutritional factors in cassava root

Whole fresh cassava root contains cyanogenic glycosides of two types, primarily linamarin (93%) and some lotaustralin (7%). Linamarin is chemically similar to glucose but is converted to cyanide (ion) in the presence of linamarase, a naturally occurring enzyme in cassava. Linamarin in cassava can vary from 2 to 395 mg/100 kg of fresh cassava root, depending on the variety (Yeoh and Yruong 1993). In the whole plant, both linamarin and lotaustralin are synthesised from amino acids.

$$\text{L-valine} \longrightarrow \text{Linamarine}$$
$$\text{L-isoleucine} \longrightarrow \text{Lotaustraline}$$
$$\text{Cyanogenic glucoside} \xrightarrow{\text{Linamarase}} \text{Glucose} + \text{Aglycon}$$
$$\text{Aglycon} \xrightleftharpoons{\text{Hydroxynitrilyase}} \text{HCN} + \text{Aldehyde or cetone}$$

Fresh cassava root contains 0.44 mg HCN/g (Udedibie et al 2004), while the meal form contains less than 40 mg/kg and can be fed to broiler chicks at 500 g/kg without any adverse effects (Panigrahi et al 1992). A later study by Panigrahi (1996) suggested that low-cyanide cassava root meals may be incorporated in nutritionally-balanced poultry diets at between 500 and 600 g/kg without any reduction in weight gain or egg production. However, an excess of cyanide content at 100 mg/kg diet appeared to adversely affect broiler performance, and laying hens may be affected by levels as low as 25 mg total cyanide/kg diet (Panigrahi 1996).

3.4.2 Sweet potato tuber (Ipomoea batatas (L.) Lam)

Sweet potato tubers are grown in many places by rural smallholders in order to obtain starchy tubers for food and some cash. The small tubers and leftovers from selling to market are an alternative for feeding their animals, such as pigs and poultry. The remaining foliage from harvesting the tubers can also be used as a protein feed for all kinds of animal. The productive potential of sweet potato tubers can reach from 24 to 36 t/ha/crop of roots (Morales 1980) and the foliage production can vary from 4.3-6 t DM/ha/crop (Ruiz et al 1980).

Chemical composition and utilization of sweet potato tuber in chicken diets

The main nutritive component in sweet potato is its starch content, and it is also a source of vitamins. Sweet potato tubers have a low content of protein, fat and fiber, but the high nitrogen free extract fraction in the tuber is indicative of its potential value as an energy source. Carbohydrates in sweet potato tubers generally make up between 80-90% of the dry weight of the roots. However, the uncooked starch of the sweet potato is very resistant to hydrolysis by amylase (Cerning Beroard and Le

Dividich 1976). Amino acid analysis of sweet potato tubers indicates them to be of good nutritional quality but deficient in total sulfur amino acids and lysine (Fuller and Chamberlain 1982).

Sweet potato tuber and foliage have been evaluated as feed for poultry. Turner et al (1976) examined various diets consisting of cooked sweet potato as a protein supplement for poultry. Chicks fed on a starter feed reached slaughter weight sooner than when fed on sweet potato diets. However, with the latter, the broilers had a higher dressing-out percentage. Yoshida and Morimoto (1958) reported that the carbohydrate fraction in sweet potato to be about 90 % digestible in chicks. Tewe (1994) reported that using sun-dried and oven-dried sweet potato replacing maize at 0, 50, and 100% in broiler rations reduced body weight gain and nutrient utilization when compared with the maize-based control diet. The broiler performance was better with the oven-dried rations, and it can replace maize at up to 50% in broiler rations. Performance was optimal at 30% replacement of maize with sweet potato.

Anti-nutritional factors in sweet potato tuber

Sweet potatoes contain trypsin inhibitors ranging from 90 % in some varieties to 20 % in others (Lin & Chen 1985) which may reduce ability of animals to utilize protein if eaten raw. These antinutritional factors also caused low dry matter digestibility and low metabolizable protein and energy values, even when the rations contained adequate and high quality proteins in animal feed (Gerpacio et al 1978). However, these trypsin inhibitors do not survive when cooking and are of no consequence in cooked tubers (Collins 1995). Preheating can also destroy or reduce these trypsin inhibitors. Therefore, cooking is necessary on account of two factors, starch digestibility and the presence of trypsin inhibitor. Sasi Kiran and Padmaja (2003) reported that when sweet potato tuber was cooked, between 17 and 31 % trypsin inhibitor activity was remained and when it was prepared into flour, only 5-12 % trypsin inhibitor activity was found.

3.4.3 Banana fruit (Musa acuminata Colla)

In the uplands of Cambodia and Laos, the banana is usually grown by farmers and sold for cash. The fruits are sold at a low price, especially those fallen from the bunch, and are bought to use as monkey or human feed, for example as roasted banana and banana rice cake. Farmers can get less benefit if they sell these undesirable bananas, but they can be processed for use as animal feed. Feeding bananas to animals has been relatively neglected. This is largely because bananas are principally a human food, but is also partly attributable to the fact that their value as animal feed has not been adequately studied (Chenost et al 1969; FAO 1969). FAO (1975) reported that an estimated 7 to 10 million tons of the 36 million ton world banana production per year (20 to 30 %) could be recovered for use as animal feed.

Composition and utilization of banana fruit for poultry feeding

The composition of all banana varieties is determined chiefly by the degree of ripeness. Bananas have high water content (78 to 80 %). In the green state, in which they are generally picked and packed, the dry matter consists mainly of starch (72 %), which on ripening changes into simple sugars (saccharose, glucose and fructose). The cellulose content is low (3 to 4 %) and most of it is found in the skin. The inorganic fraction is poor, with low levels of Ca and P, but it is rich in K. Whether green or ripe, the banana has low protein content and is deficient in lysine and in the sulphur-containing amino acids (2.3– 2.9 g/16 g N) (Le Dividich et al 1976).

In banana exporting countries, large quantities of rejected bananas are often available for animal feed. Banana fruits have been used for feeding pigs in the fresh and ripe form (Le Dividich and Canope 1975). They can also be used for ruminant feeding in the form of pulp flour, or fresh or ensiled fruit (Thivend et al 1972; Spiro 1973; Rihs et al 1975). There seems to be little or no research on the use of fresh banana fruit for poultry feed. From personal observation, chickens eat banana if they find it on the ground. Banana in the form of meal has been used in poultry diets, but high levels tend to depress growth and reduce feed efficiency (Sharrock 1996).

Anti-nutritional factors in banana fruit

While banana is generally harmless to humans and animals, it does contain substances that are harmful when ingested in high quantities. The substances found in banana are tannins (3.40 mg/g), oxalate (4.50 mg/g) and phytate (2.88 mg/g). However, the concentration of these anti-nutrients is not particularly high, which means it needs little or no processing before it is used for human and animal feed (Onibon et al 2007). Moreover, tannins in banana are only slightly polymerized in the green fruit and therefore inhibit the action of enzymes. In the ripe fruit, however, polymerization is higher (Le Dividich et al 1976).

Table 3: Composition and nutritional value of the edible part of raw carbohydrate feeds (g/100 g sample)

Nutrient	Cassava root	Sweet potato tuber	Banana fruit
Water	59.7	77.3	74.9
Energy (kcal)	160.0	86.0	89.0
Energy (kJ)	667.0	359.0	371.0
Protein	1.4	1.6	1.1
Total lipid (fat)	0.3	0.1	0.3
Ash	0.6	1.0	0.8
Carbohydrate, by difference	38.1	20.1	22.8
Fiber	1.8	3.0	2.6
Sugars, total	1.7	4.2	12.2
Sucrose	-	2.5	2.4
Glucose (dextrose)	-	1.0	5.0
Fructose	-	0.7	4.9
Starch	-	12.7	5.4

Source :USDA 2009

4. Conclusions

In short:

- Most smallholders in developing countries raise indigenous chickens, and these scavenging village chickens play a significant role in poverty alleviation.
- The cafeteria feeding system is a popular method for scavenging chickens, which gives them the opportunity to select nutrients according to their physiological demands.
- Providing available carbohydrate feeds, such as cassava root, sweet potato tuber and banana fruit for scavenging birds provides energy to support their activities in searching for their required food.

- Some green forages, such as duckweed, water spinach and taro leaf are also important in the scavenging system as they provide protein, minerals and vitamins to enhance the growth of the scavenging chicken.

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Feed selection and growth performance of local chickens offered different carbohydrate sources in fresh and dried form supplemented with protein-rich forages

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Abstract

A series of experiments were conducted at the farm of CelAgrid in Kandal Province, Cambodia.

Experiment 1 consisted of two related cafeteria trials which were conducted to determine the feed preferences of local chickens when fed different feeds separately. The first trial was conducted for 4 weeks with 40 chickens allocated to 4 pens with 10 birds per pen. They were given free access to three types of chopped green forage (taro leaf, duckweed and water spinach) and broken rice as source of energy. The daily dry matter (DM) intake of duckweed (3.9 g) was higher than that of water spinach (2.1 g), while the intake of taro leaf was relatively low (0.02 g). The crude protein (CP) intakes were 1.1 g, 0.5 g and 0.02 g for duckweed, water spinach and taro leaf, respectively. The second trial was conducted with the same duration and the same number of birds per pen. They were given free access to 3 types of fresh chopped carbohydrate feed (cassava root, sweet potato tuber and banana fruit) and duckweed as the only source of protein The daily DM and CP intakes of sweet potato and cassava root were 16 g and 0.5 g for DM and CP, respectively, while the banana fruit intake was low.

Experiment 2 was carried out for 2 weeks with 240 local chickens at the age of 60 days (144 females and 96 males). The chicks were housed 10 per pen (4 males and 6 females). The experiment was a 4*2 factorial arrangement in a completely randomized design (CRD) with 3 replications. The chickens had free access to each of the carbohydrate feeds (broken rice, cassava root, sweet potato tuber, and banana fruit) and each of two proteins feeds (soybean meal and duckweed). The total daily DM intake of the broken rice diet was 32.0 g, and was 26.6 g, 24.0 g and 22.5 g of fresh cassava root, sweet potato tuber and banana fruit, respectively. The CP intake of chickens on duckweed was 19.2 g, which was lower than of those fed on soybean meal (34 g). The CP intake of chickens fed different carbohydrates was similar (5-7 g) but the CP intake of the chickens fed on soybean meal was higher (10.4 g) than on duckweed (2 g). The chicks did not gain weight on duckweed, except on the broken rice diet, and had normal growth on soybean meal (4-6 g). Through linear regression analysis, the DM intake was shown to have close relationship to the average daily gain (R^2=0.70).

Experiment 3 was carried out for 2 weeks with 210 local chickens (144 females and 96 males) at the age of 60 days. The chicks were housed 10 per pen (4 males and 6 females) and were allotted randomly to treatment. The experiment was 3*2 factorial arrangement in a completely randomized design (CRD) with 3 replications. Chickens had free access to each of three kinds of carbohydrate (cassava root, sweet potato tuber, and banana fruit) in the fresh form or as meal. The total daily DM intakes of the cassava root, sweet potato tuber and banana fruit diets were 21.0 g, 19.6 g and 29.0 g, respectively. The total intake of chickens fed the different forms of carbohydrate feed was not different and was around 20 g/day. The total daily CP intake was similar between the chickens fed on different types or forms of carbohydrate feed, and was around 1.5 g. Linear regression analysis showed that the weight change of the chickens had a close relationship with the CP intake ($p=0.011$, $r^2=0.75$).

Key word: *Cafeteria, green forage, duckweed, water spinach, taro leaves, carbohydrate feeds, cassava root, sweet potato tuber, banana fruit*

1. Introduction

The rearing of local chickens by smallholder farmers in developing countries is based on scavenging and providing some extra feed. Available low cost feeds that farmers can use to supplement their chickens could be by-products and surplus products that can provide energy or protein. Some locally available feeds, such as cassava root, sweet potato tuber and banana fruit, are good sources of energy but are not used widely by farmers even though they are abundant at harvesting time or the price is low. However, these feeds contain low protein, vitamins, and minerals (Silvestre & Arraudeau 1983; Cerning Beroard and Le Dividich 1976; Le Dividich et al 1976). Therefore, if farmers use them to provide energy to chickens to support activities during scavenging, some protein feeds should be also supplemented and these should be cheap and high in nutrients, such as green forages, including duckweed, water spinach, sweet potato leaf and taro leaf. The crude protein (CP) contents of duckweed, water spinach and taro leaf are 39.3 % (Bui Xuan Men et al 1996), 35.9 % (Nguyen Thi Thuy and Ogle 2005) and 25 % (FAO 1993), respectively. These indicate a good potential for smallholder farmers to improve the performance of their scavenging chickens. However, there is a concern in using green forages for chickens because they contain high levels of fiber, which has been associated with reducing nutrient digestibility (Just 1982; Graham 1988).

Therefore, these studies were conducted to evaluate potential carbohydrate feeds to determine whether they could be used fresh or should be processed before they are fed to provide energy to local chickens, and also how they could be used with green protein-rich forages.

Experiment 1. Preference of local chickens for different green forages and carbohydrate feeds

2. Material and methods

2.1. Duration and location

The experiment consisted of two related trials which were conducted for four weeks each in the farm of the Center for Livestock and Agriculture Development (CelAgrid), which is about 19 km south of Phnom Penh City.

2.2 Experimental design

2.2.1 Green forages selection trial

Three types of green forage (taro leaf, duckweed and water spinach) were fed (Table 1) with broken rice as the main source of energy. There were 10 chicks per each of the 4 pens. The breeds of chicken were Sampov (local fowl) and Kandong (slow feathering) and they were 60 days old. Each forage and broken rice was offered separately. All the green forages were offered in the same amount (DM basis) during 10 days of the adaptation period. Subsequently, the amounts were changed according to the preference of the chickens. The green forages were offered 4-5 times each day.

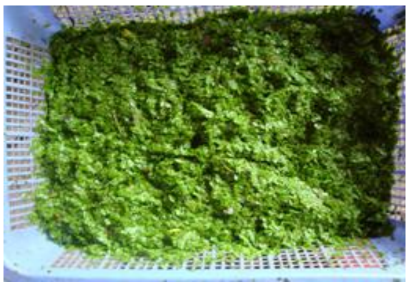


Photo 1: Duckweed

Photo 2: Water spinach

Photo 3: Taro leaf

2.2.2. Cassava root, sweet potato tuber and banana fruit selection trial

Carbohydrate feeds (cassava root, sweet potato tuber and banana fruit) were randomly allocated to each of the 4 pens and with 10 chicks per pen, and offered separately in each pen. The green forage (duckweed) most preferred by the chickens in the first trial was selected and offered as protein feed. All carbohydrate feeds were offered in the same amount of DM during 10 days of the adaptation period and then the amounts were changed according to the observed intakes. The fresh carbohydrates were offered 4-5 times per day.

Photo 4: Duckweed

Photo 5: Water spinach

Photo 6: Banana fruit

Table 1: Experimental layout of the two trials

Pen	Green forages selection trial		
1	Duck weed	Taro leaves	Water spinach
2	Duck weed	Water spinach	Taro leaves
3	Water spinach	Taro leaves	Duck weed
4	Duck weed	Water spinach	Taro leaves
Pen	**Carbohydrate selection trial**		
1	Cassava root	Sweet potato tuber	Banana fruit
2	Banana fruit	Sweet potato tuber	Cassava root
3	Sweet potato tuber	Cassava root	Banana fruit
4	Banana fruit	Sweet potato tuber	Cassava root

2.3. Data collection and feed analysis

Feed offer and refusals were weighed once per day in the morning to estimate the intake. Samples of feeds were taken for analysis of DM and CP. The chickens were weighed every week.

Photo 7: Weighing feed

Photo 8: Weighing chickens

2.4. Statistical analysis

Feed intake was analyzed using the GLM option of the ANOVA program in Minitab 14 (2004) software. Sources of variation were: green forages and error (for the green forage selection trial) and carbohydrate feeds and error (for carbohydrate selection trial).

3. Results

3.1. Chemical composition of the experimental feeds

Both water spinach and taro leaves had higher DM content compared with duckweed, while duckweed had higher protein content in DM basis (Table 1). Crude protein (CP) levels were similar for water spinach and taro leaf, with a higher level for the duckweed.

Table 1: Chemical composition of feeds

	DM, %	CP, % in DM
Trial 1 (Protein-rich forages)		
Duckweed	6.7	29.2
Water spinach	11.4	24.0
Taro leaf	13.2	25.2
Broken rice	89.2	8.11
Trial 2 (Carbohydrate feeds)		
Duckweed	6.3	29
Cassava root	37.0	2.3
Sweet potato tuber	25.4	3.0
Banana fruit	26.9	3.4

3.2. Protein-rich forages intake (PRF)

The DM intake of duckweed, water spinach and taro leaves was 3.9 g, 2.0 g and 0.02 g per day, respectively (Table 2). The total intake of forages accounted for 18% of the total DM intake and 43% of the CP intake (Figure 1).

Table 2: Daily intake of different protein-rich forages and of broken rice, each offered *ad libitum*, g/head

	Duckweed	Water spinach	Taro leaves	SEM	Probability	PRF	Broken rice
Fresh intake	61^c	22^b	0.14^a	0.90	***	83.1	31
DM intake	4^c	$2.^b$	0.023^a	0.08	***	6.0	28
CP intake	1.15^c	0.5^b	0.006^a	0.03	***	1.7	2.2

a,b,c Means within rows with differing superscript letters are significantly different (P<0.05) (a<b<c)
*** p<0.001; PRF: total intake of protein rich forages

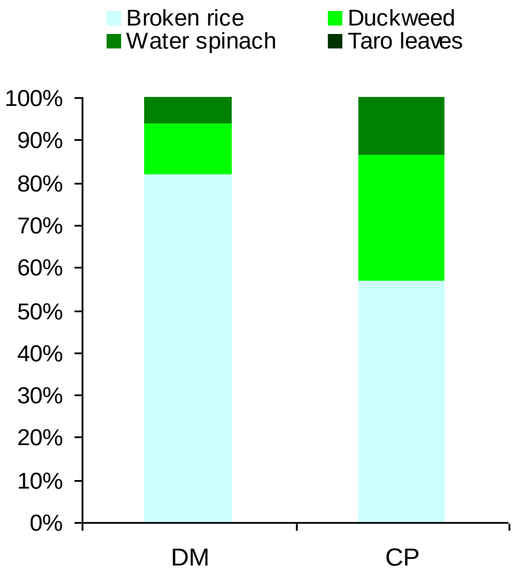
3.3. Roots/tubers/fruits intake (RTF)

The carbohydrate components accounted for 81% of the total DM intake and 29% of the duckweed intake (Figure 2). Among the carbohydrates, the fresh sweet potato tubers and cassava roots were consumed in similar quantities (together accounting for almost all the intake of the carbohydrate component) with fresh banana fruit being eaten in insignificant amounts (Table 3).

Table 3. Daily intake of different carbohydrate feeds and duckweed, each offered ad libitum, g/head

	Cassava root	Sweet potato tuber	Banana fruit	SEM	Probability	RTF	Duckweed
Fresh intake	36^b	61^c	2^a	1.6	***	100	116
DM intake	16^b	17^b	0.6^a	0.5	***	34	8
CP intake	0.4^b	0.5^b	0.02^a	0.01	***	0.9	2.4

a,b,c Mean within rows with differing superscript letters are significantly different (P<0.05) (a<b<c)
*** p<0.001; RTF: total intake of root, tuber and fruit



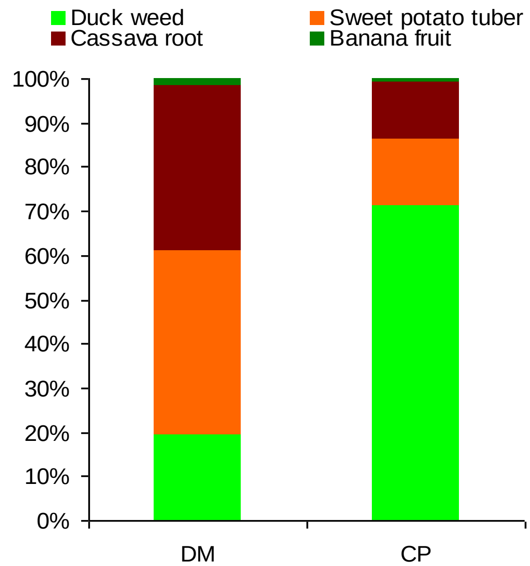


Figure 1. Proportions (%) of dietary DM and CP consumed by local chickens with free access to duckweed, water spinach, taro leaves and broken rice

Figure 2. Proportions (%) of dietary DM and CP consumed by local chickens with free access to banana fruit, cassava roots, sweet potato tubers and duckweed

When the birds were fed cassava root, sweet potato tuber and banana fruit with duckweed, they were less able to satisfy their nutrient requirements than when they were offered the green forage with broken rice. The total CP intake from the duckweed in the RTF (2.4 g/day) was greater than from the forages in PRF (1.7 g/day). However, in the PRF trial the broken rice supplied more crude protein (2.2 g/day) than the roots-tubers-fruit in RTF (0.96 g/day).

Table 4: Changes in live weight, feed intake and DM conversion in cafeteria trials with mainly protein-rich forages (PRF) or roots/tubers/fruits (RTF)

	PRF	RTF
Initial weight, g	276	497
Final weight, g	455	501
Daily gain, g/day	6.5	0.2
DM intake, g/day	34	42
DM intake, g/kg LW	98	84
DM intake, % of body weight	12.3	8.5
CP intake, g/day	4.0	3.3
DM conversion ratio	6.0	81
CP intake, % in DM	12	8.0

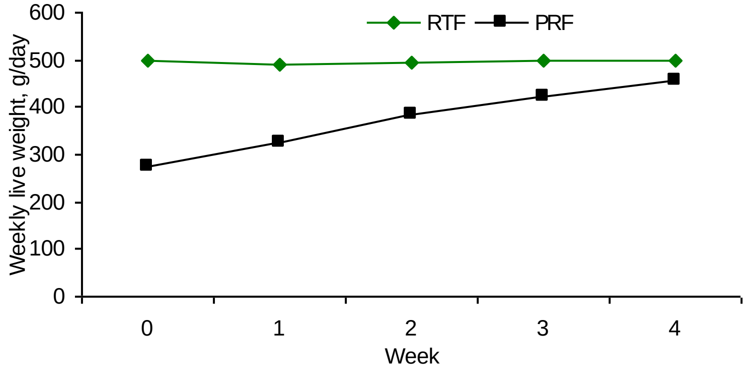


Figure 3: Changes in live weight of local chickens in cafeteria trials with protein-rich forages (PRF) or carbohydrates (RTF) feeds

4. Discussion

Among the green forages (duckweed, water spinach and taro leaf) that were fed to the local chickens in the cafeteria system, duckweed was the most preferred, followed by water spinach, while taro leaf was the least preferred. It was observed that when some chickens ate taro leaf, they consumed a little and walked away, while some chickens did not consume it at all. Every feeding time, chickens ran to the trough with duckweed first, and then to the trough with the other feeds. The fresh intake of duckweed in this study (61-116 g/day) was higher than that reported by Hong Samnang (1999), which was 30-40 g/day as a supplement to broken rice, and by Rodriguez and Preston (1999) (30 to 36 g/day) with rice bran as the supplement. Nguyen Thi Kim Khang and Ogle (2004) found out that Tau Vang chickens confined on-station consumed 40 g/day of fresh duckweed as a supplement with concentrate. Nguyen Thi Thuy and Ogle (2005) compared three kinds of green forage as protein feed and found that the daily DM intakes of duckweed, water spinach and sweet potato leaves were 3.3, 1.8 and 2.8 g respectively, which for duckweed and water spinach were similar to the intakes in the present study (3.9 and 2.1 g/day, respectively). However, if compared to the preferences of indigenous chickens under scavenging conditions, they are diverse, as Okitoi et al (1999) and Tuitoek et al *(*2000) reported that chickens prefer grain (49-54%), kitchen waste (13.5-14.5%) insects and worms (6-8%) and green forages (5-15%).

It has been observed that chickens in the free range system pick at carbohydrate feeds such as cassava root, sweet potato tuber and banana fruit, but it is not known whether they really appreciate them. In the present experiment, when offered the three kinds of carbohydrate feed, the chickens spent most time at the trough with cassava root and sweet potato tuber, and ate banana fruit only in small amounts. The DM intake of banana fruit was 16 times smaller than of cassava roots and sweet potato tuber. Comparing the foraging behavior of scavenging chickens, Okitoi et al (2009) reported that the highest frequency of dietary components retrieved from crops contents of scavenging indigenous chickens in Western Kenya in two seasons was grass, followed by cassava root and maize.

5. Conclusion

It is concluded that among the green forages, duckweed and water spinach were preferred, and among the carbohydrate feeds cassava roots and sweet potato tuber were preferred by local chickens.

Experiment 2. Comparison of different sources of fresh carbohydrate with soybean meal or green forage as protein sources for local chickens

6. Materials and methods

6.1. Location and duration

The experiment was conducted for two weeks in the farm of the Center for Livestock and Agriculture Development (CelAgrid).

6.2. Materials

The chicks were hatched by electric incubator at CelAgrid and raised until they were 60 days old. The carbohydrate feeds were cassava roots, sweet potato tubers, banana fruit and broken rice, and soybean meal and duckweed were the sources of protein. Duckweed was the most preferred green forage as shown in the results from Experiment 1. Duckweed was cultivated in the canals at the CelAgrid farm that are fertilized with effluent from pig manure.

6.3. Experimental design

The experiment was designed as a 4*2 factorial arrangement in a completely randomized design (CRD) with 3 replications. There were 10 chickens per replication (pen) (4 males and 6 females per pen). The factors were:

Carbohydrate feeds

- Broken rice (BR)
- Cassava root (CR)
- Sweet potato tuber (SP)
- Banana fruit (BF)

Protein feeds

- Soybean meal (SB)
- Duckweed (DW)

Table 5: Individual treatments

	BR	**CR**	**SP**	**BF**
SB	BRSB	CRSB	SPSB	BFSB
DW	BRDW	CRDW	SPDW	BFDW

Individual treatments were:

- BRSB: Broken rice + Soybean meal (control treatment)
- CRSB: Cassava root + Soybean meal
- SPSB: Sweet potato tuber + Soybean meal
- BFSB: Green banana fruit + Soybean meal
- BRDW: Broken rice + Duckweed
- CRDW: Cassava root + Duckweed
- SPDW: Sweet potato tuber + Duckweed
- BFDW: Green banana fruit + Duckweed

Table 6: Experimental layout

BRDW	CRSB	BRSB	CRSB	BRSB	SPDW	BFSB	CRDW
BFSB	BFDW	CRDW	BRSB	BFDW	BFDW	SPSB	SPDW
BRDW	CRSB	SPDW	SPSB	CRDW	BRDW	SPSB	BFSB

6.4. Housing system

The experimental pens were 24 compartments (each with an area of 7 x 1.5 m) built using wooden and bamboo frames and metal wire mesh. Two feeders (one for the energy feed and one for the protein feed) and one water trough were put in each pen.

6.5. Experimental feeds and feeding

Chickens had free access to the carbohydrate and protein feeds. The whole carbohydrate feeds were chopped into small pieces and fed fresh. Duckweed was collected and pressed by hand to reduce the water content before feeding. The chemical composition of the experimental feeds is shown in Table 7.

Table 7: Chemical composition of feeds used in the experiment

Nutrients	Broken rice	Cassava root	Sweet potato tuber	Banana fruit	Duckweed	Soybean meal
DM, %	93.3	48.8	35.6	31.5	6.3	87.9
CP, % in DM	8.7	3.5	3.2	3.0	30.8	50.7

6.6. Animals and management

Two hundred and forty local chickens of the same breed were used in the experiment. They were kept 10 per pen (4 males and 6 females) where they had free access to the feed and water. Before starting the experiment, the chickens were vaccinated against Newcastle and Fowl Pox diseases. Fresh feed was provided 3-4 times per day.

6.7. Data collection

The chickens were adapted to the experimental feeds for 10 days before starting the collection of data. Feed offer and refusals were weighed and recorded daily before and after each of the meals. The weights of chickens were taken every 7 days. Samples of feed were taken for analysis every 7 days.

6.8. Chemical analysis

The feeds offered and refusals were analyzed to determine DM using microwave radiation (Undersander et al 1993) and N and ash following the methods of AOAC (1990).

6.9. Statistical Analysis

Dry matter feed intake, crude protein intake and live weight gain were analyzed using the General Linear Model (GLM) option of the ANOVA software of Minitab 14 (2004). The sources of variation were: carbohydrate feeds, protein feeds, interaction of carbohydrate feeds*protein feeds and error.

7. Results

Growth rate and feed intake

There were significant interactions for all measurements of feed intake and live weight change (Table 8), which showed contrasting results according to whether the protein source was soybean meal or duckweed. On soybean meal the chickens gained live weight on all the carbohydrate sources, with the best result on broken rice, followed by sweet potato root, and with the poorest growth on cassava root and banana fruit (Table 8). In contrast, with duckweed as the protein source, the chickens lost weight on all the carbohydrate feeds other than broken rice for which the growth rate was the same as with soybean. The differences in live weight change appear to have been caused by differences in feed intake, as live weight gain was linearly related (R^2 = 0.7; P=0.001) with DM intake.

Table 8: Live weight change and DM intake of local chicken fed different carbohydrate sources and protein feeds

	Energy feed (E)					**Protein feed (P)**			**Probability**		
	Broken rice	**Cassava root**	**Sweet potato**	**Banana fruit**	**SEM**	**Duck weed**	**Soybean meal**	**SEM**	**E**	**P**	**E*P**
Initial weight, g	313	344	337	264	26	290	339	18	ns	ns	ns
Final weight, g	398^b	356^b	362^b	272^a	26	290	404	19	*	***	ns
ADG, g	6.0^b	1.0^a	2.0^a	0.6^a	0.5	-0.01	5	0.4	***	***	***
DM intake, g/day	33^b	27^a	24^a	23^a	1.4	19	34	1.0	***	***	***
DM intake, % of BW	10.6^b	7.8^a	6.9^a	8.4^a	0.5	6.8	10.1	0.3	***	***	*
CP intake, g/day	5.0	6.0	7.0	6.4	0.6	2.0	10.4	0.4	ns	***	***
CP intake, % in DM	15^c	19^a	24^b	23^b	0.8	10	31	0.5	***	***	***

a,b,c Means within rows with differing superscript letters are significantly different (P<0.05) (a<b<c); * p<0.05, *** p<0.001

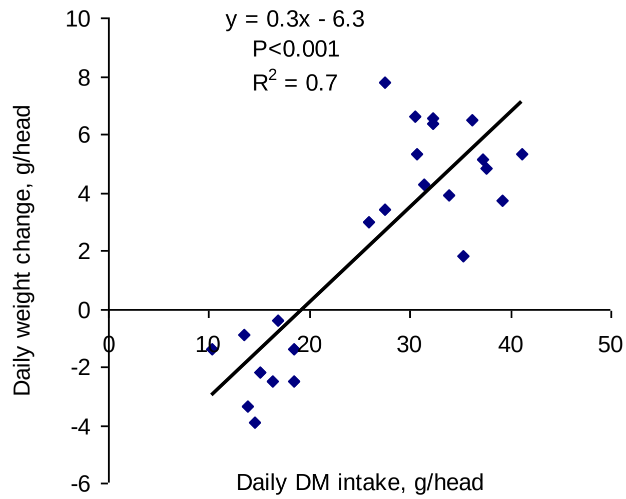


Figure 4. Relationship between DM intake and live weight gain of chickens fed different sources of carbohydrate and protein

Table 9: Daily DM intake of local chickens fed different energy and protein feeds

	Energy feed (E)					Protein feed (P)			Probability		
	Broken rice	Cassava root	Sweet potato	Banana fruit	SEM	Duck weed	Soybean meal	SEM	E	P	E*P
Daily DM intake, g/head											
Energy feed	26^{c}	15^{ab}	10^{a}	10^{a}	0.9	15	15	0.6	***	ns	**
Protein feed	7.0^{a}	12^{b}	14^{b}	12^{b}	1.1	4.0	19	0.8	***	***	***
Total	**33^{b}**	**27^{a}**	**24^{a}**	**22^{a}**	**1.4**	**19**	**34**	**1.0**	***	***	***
CP intake, g/head											
Energy feed	2.0^{a}	0.5^{b}	0.3^{b}	0.3^{b}	0.06	1.0	1	0.04	***	ns	ns
Protein feed	3.0^{a}	6.0^{b}	7.0^{b}	6.0^{b}	0.6	1.0	9.0	0.4	***	***	***
Total	**5.0**	**6.5**	**7.3**	**6.3**	**0.66**	**2.0**	**10**	**0.4**	ns	***	***

a,b,c Means within rows with differing superscript letters are significantly different (P<0.05) (a<b<c) ** p<0.01, *** p<0.001

Table 10: Daily DM and CP intake and average weight gain of local chickens fed different energy and protein feeds

	Broken rice		Cassava root		Sweet potato tuber		Banana fruit		SEM/P
	Duckweed	Soybean	Duckweed	Soybean	Duckweed	Soybean	Duckweed	Soybean	
Daily DM intake, g/head									
Energy feed	27	26	13	17	9	11	13	7	1.2/**
Protein feed	5.0	8.0	5.0	19	4.0	25	3.0	23	1.6/***
Total	**32**	**34**	**18**	**36**	**13**	**36**	**16**	**30**	**2.0/*** **
CP intake, g/head									
Energy feed	2.3	2.2	0.4	0.5	0.3	0.3	0.4	0.2	0.08/ns
Protein feed	1.4	4.3	1.4	9.7	1.1	13	0.7	11.4	0.8/***
Total	**3.7**	**6.5**	**1.8**	**10.3**	**1.3**	**13.1**	**1.1**	**11.6**	**0.8/*** **
DM intake, % of BW	10.1	11.1	6.1	9.5	4.2	9.5	6.6	10.2	0.7/*
CP, % in DM	12	19	11	28	11	37	7.0	40	1.1/***
ADG, g/day	6.2	6	-2.04	3.8	-1.9	5.5	-2.3	3.4	0.8/***

* p<0.05, ** p<0.01, *** p<0.001

8. Discussion

In this study, the live weight gain of chickens fed the control diet (broken rice with soybean meal and broken rice with duckweed) was around 6 g/day which was similar to those fed on broken rice and green forages in Experiment 1, in which they had similar CP intake (12 % of diet DM). Kingori et al (2003) reported that when indigenous chickens were fed a diet containing 12% CP, they gained 5.8 g/day but they can gain more weight (up to 11.5 g/day) if the diet contains the required protein (16 %) in a balanced diet. However Hong Samnang (1999) reported that the live weight gain of experimental indigenous chickens was 12.5 g/day on broken rice plus duckweed, up to 14.5 g/day on broken rice plus soybean meal and 10 g/day on broken rice alone. One of the reasons is that initial weight of his experimental chickens was higher than that in the present study and the chickens were scavenging, and thus the additional nutrient requirement could be compensated for by the scavenging feed resources. If compared to the results of Nguyen Thi Thuy and Ogle (2005), the live weight gain was higher than that in the present study, and was 20.4 g/day using balanced mixed feed with duckweed and with Loung Phoung chickens. Also, the CP in diet DM was 16.8%, which was higher than that in the present study.

In this study, if the broken rice was replaced by fresh carbohydrate feeds, such as cassava root, sweet potato tuber and banana fruit, there were negative effects on feed intake and live weight gain. The chickens consumed lower amounts of these fresh feeds compared to broken rice and consumed more protein feed if soybean meal was used. They consumed the same amount of duckweed if it was used as protein feed. On the diet of duckweed as protein feed, chickens lost 2 g/day of live weight when they were fed fresh cassava root, sweet potato and banana fruit. Although the protein intake was below the requirement of growing chickens of 14-21 weeks, the other important limitation which prevented the optimal utilization of nutrients was the anti-nutritional factors in the feed.

Fresh whole cassava root can contain 0.44 mg HCN/g (Panigrahi et al 1992). Feeding of fresh cassava roots may cause cyanide toxicity, depending on the cyanide content in the tubers (Mathur et al 1969). Panigrahi (1996) reported that an excess of cyanide content of 100 mg/kg diet appears to adversely affect broiler performance, and laying hens may be affected by levels as low as 25 mg total cyanide/kg diet. Fresh banana fruit also contains tannin (3.40 mg/g), oxalate (4.50 mg/g) and phytate (2.88 mg/g), but the quantity of these anti-nutrients is not excessive (Onibon et al 2007). Fresh sweet potatoes contain trypsin inhibitors, ranging from 90 % inhibition in some varieties to 20 % in others (Lin & Chen 1985), which cause low dry matter digestibility and low metabolizable protein and energy values, even when the rations contained adequate and high quality proteins (Gerpacio et al 1978).

9. Conclusions

Among the energy feeds, cassava roots seem to be the morst promising, as chickens consumed higher amounts. However, processing techniques need be studied, such boiling whole roots, boiling chops or making into chips.

Experiment 3. Effect of fresh or dried cassava roots, sweeet potato tubers and banana fruit, as energy feeds, with fresh duckweed as the protein source on the growth of local chickens

Objective

From the results of Experiment 2 it was hypothesized that the low intakes of the cassava roots, sweet potato tubers and banana fruit may have been caused by their high moisture content when they were offered fresh. Therefore the aim of this experiment was to evaluate the effect of sun-drying and grinding of energy feeds on the growth rate of chickens.

10. Materials and methods

10.1. Materials

The chicks were hatched by incubator in CelAgrid and raised until they were 90 days old. The carbohydrate feeds (cassava roots, sweet potato tubers, banana fruit and broken rice) were bought from a local market every 2-3 days. Some of them were dried under sunlight and ground into the meal form. The same duckweed was selected for use as protein source.

10.2. Experimental design

The experiment was designed as 3*2 factorial arrangement plus one control treatment in a completely randomized design (CRD) with 3 replications. There were 10 chickens per replication (pen) (4 males and 6 females). The factors were:

Carbohydrate feeds

- Cassava root (CR)
- Sweet potato tuber (SP)
- Banana fruit (BF)

Processing

- Fresh
- Sun-dried and ground

Table 11: Individual treatments

	CR	**SP**	**BF**
Fresh	FRCR	FRSP	FRBF
Sun-dried	SDCR	SDSP	SDBF

Individual treatments were:

- FRCR: Fresh cassava root
- FRSP: Fresh sweet potato tuber
- FRBF: Fresh banana fruit
- SDCR: Sun-dried cassava root
- SDSP: Sun-dried sweet potato tuber
- SDBF: Sun-dried banana fruit
- BR: Broken rice as control diet

Table 12: Experimental layout

BR	SDCR	SDCR	BR	FRSP	SDBF	FRCA
SDBF	FRBF	FRCA	BR	FRBF	FRBF	SDSP
FRSP	SDCR	FRSP	SDSP	FRCA	SDSP	SDBF

10.3. Experimental feeds and feeding

Chickens had free access to the carbohydrate feeds and duckweed. The whole fresh carbohydrate feeds were chopped into small pieces before feeding, while the meals were fed directly. Duckweed was collected and pressed by hand to reduce the water content before feeding. The chemical composition of the diets is shown in Table 13.

Table 13: Chemical composition of feeds used in the experiment

Nutrients	Broken rice	Duckweed	Cassava root		Sweet potato tuber		Banana fruit	
			Fresh	Sun-dried	Fresh	Sun-dried	Fresh	Sun-dried
DM, %	88.5	6.9	34.8	88.3	33.3	88.3	30.5	84.6
CP, % in DM	6.1	29.8	2.7	2.4	2.9	2.1	2.8	2.6

10.4. Animals and management

In total 210 local chickens were used in the experiment. They were kept 10 per pen (4 males and 6 females) where they had free access to the feeds and water. Before starting the experiment, the chickens were vaccinated against Newcastle and Fowl Pox diseases. The chickens were offered feed 3-4 times per day.

10.5. Data collection

The chickens were adapted to the experimental feeds for 10 days before the start of data collection. Feeds offered and refused were weighed and recorded daily before and after each of the meals was provided. The weights of chickens were recorded every 7 days. Samples of feed were taken for analysis every 7 days.

10.6. Chemical analysis

The feeds offered and refused were analyzed to determine DM using microwave radiation (Undersander et al 1993) and N and ash following the methods of AOAC (1990).

10.7. Statistical Analysis

Dry matter feed intake, crude protein intake and live weight gain were analyzed by using the General Linear Model (GLM) option of the ANOVA software of Minitab 14 (2004). The sources of variation were: energy, feed type, processing type and interaction of energy feed type*processing type and error.

11. Results

Growth rate and feed intake

When given fresh or dried cassava root, sweet potato and banana fruits, the chickens lost weight, while those fed broken rice gained weight. When cassava roots were given in fresh form there was a slight gain in live weight, but on the dried root the weight change was negative (Tables 14 and 15; Figures 5 and 6). When the treatments in dry form were compared, only broken rice supported positive growth, with cassava root just maintaining the live weight, and there was an increasingly severe loss of weight on the sweet potato and banana fruit.

Table 14: Live weight change, daily DM and CP intake of local chickens fed different carbohydrate sources, either fresh or dried

	Carbohydrate type (T)				Carbohydrate processing (P)			Probability		
	Cassava	**Sweet potato**	**Banana**	**SEM**	**Dry**	**Fresh**	**SEM**	**T**	**P**	**T*P**
Initial weight, g	475	415	459	17.6	434	465	14.4	ns	ns	*
Final weight, g	482[c]	384[a]	376[a]	18.4	395	433	15	**	ns	ns
Daily weight change, g	0.5[c]	-2.2[b]	-6[a]	0.7	-2.8	-2.3	0.6	***	ns	ns
DM intake, g/day	21[b]	20[a]	29[b]	1.2	23	23	0.9	***	ns	***
DM intake, % of BW	4.5[a]	4.7[a]	6.3[b]	0.3	5.4	5	0.2	**	ns	ns
CP intake, g	1.5	1.2	1.6	0.1	1.3	1.5	0.1	ns	ns	ns
CP intake , % in DM	7.4[c]	6.2[ab]	5.4[a]	0.4	5.8	6.8	0.3	**	*	ns

*a,b,c Means within rows with differing superscript letters are significantly different (P<0.05) (a<b<c); * p<0.05, ** p<0.01, *** p<0.001*

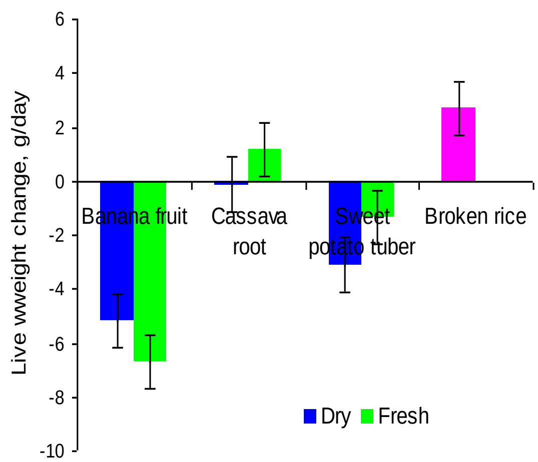


Figure 5. Mean values for live weight change of local chickens fed dufferent sources of energy feed in fresh or sun-dried form, in each case with free access to fresh duckweed; results for the control diet of broken rice and duckweed are also shown

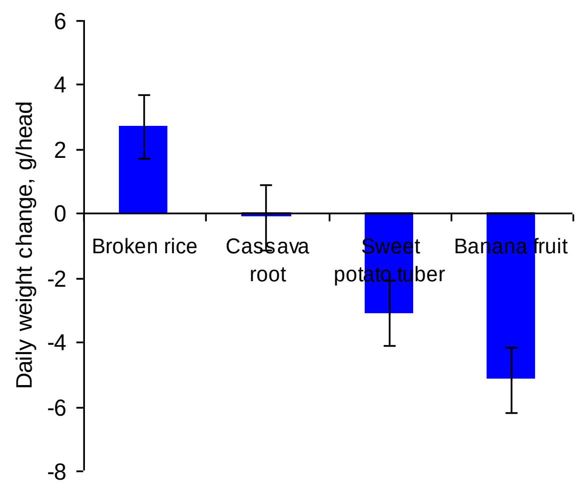


Figure 6. Mean values for live weight change of local chickens fed different sources of energy feed in dry or meal form, in each case with free access to fresh duckweed

There were differences in DM intake among the different treatments (Tables 14 and 15; Figure 10) but these showed no relationship with the growth rate (Figure 5). In contrast, there was a close relationship (R^2=0.75) between the CP content of the diet DM and the growth rate (Figure 7).

Table 15: Daily DM and CP intake of local chickens fed different carbohydrate sources, either fresh or dried

	Carbohydrate type (T)				Carbohydrate processing (P)			Probability		
	Cassava	**Sweet potato**	**Banana**	**SEM**	**Dry**	**Fresh**	**SEM**	**T**	**P**	**T*P**
DM intake, g										
Energy feed	17[a]	17[a]	26[b]	1.0	20	20	1	***	ns	***
Duckweed	4	3	3	0.4	3	3	0.3	ns	ns	ns
Total	**21[a]**	**20[a]**	**29[b]**	**1.4**	**23**	**23**	**1.3**	***	**ns**	***
CP intake, g										
Energy feed	0.4[a]	0.4[a]	0.7[b]	0.03	0.5	0.6	0.02	***	*	***
Duckweed	1.1	0.8	0.8	0.1	0.9	0.9	0.09	ns	ns	ns
Total	**1.5**	**1.2**	**1.6**	**0.1**	**1.3**	**1.5**	**0.1**	**ns**	**ns**	**ns**

*abc Mean within rows with differing superscript letters are significantly different (P<0.05) (a<b<c); * p<0.05, ** p<0.01, *** p<0.001*

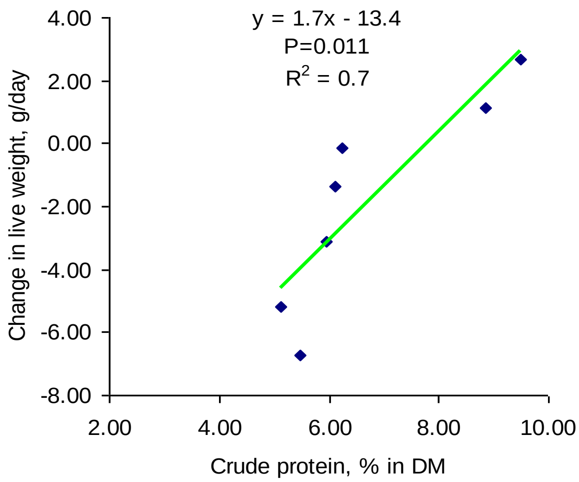


Figure 7: Relationship between % of CP in the diet and live weight change of local chickens fed different energy feeds in fresh or sun-dried form, in each case with free access to fresh duckweed

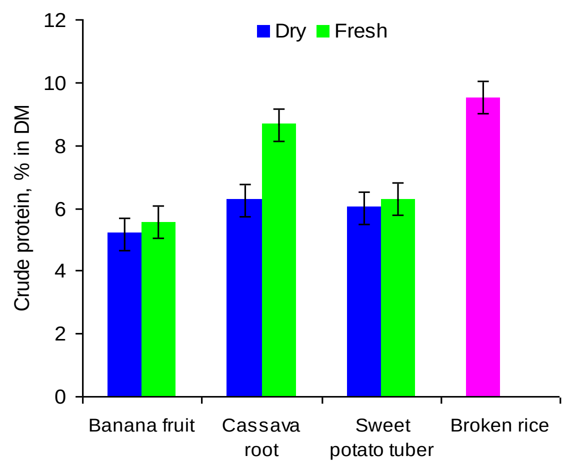


Figure 8. Mean values for the CP content of the diets of local chickens fed different energy feeds in fresh or sun-dried form, in each case with free access to fresh duckweed; results for the control diet of broken rice and duckweed are also shown

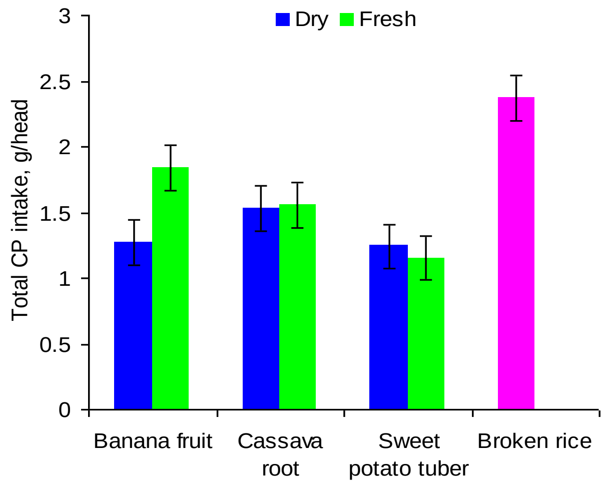


Figure 9. Mean values for CP intake of local chickens fed different energy feeds in fresh or sun-dried form, in each case with free access to fresh duckweed; results for the control diet of broken rice and duckweed are also shown

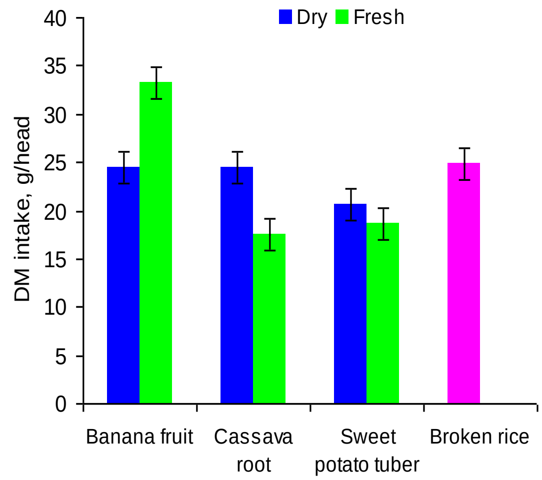


Figure 10. Mean values for DM intake of local chickens fed different energy feeds in fresh or sun-dried form, in each case with free access to fresh duckweed; results for the control diet of broken rice and duckweed are also shown

12. Discussion

The chickens on all the combindations of fresh and dried cassava root, sweet potato tubers and banana fruit, with duckweed as protein feed, lost 2 to 5 g/day of weight, while those on the broken rice control treatment gained in live weight. This result is similar to that of Experiment 2 when using the same feeds in the fresh form, and the same chicken breed, when the chickens also lost around 2 g/day. The reason could be the presence of anti-nutritional factors in the fresh form of feed, which was discussed in Experiment 2.

One of the objectives of this study was to reduce the level of anti-nutritional factors in the fresh cassava root, sweet potato tubers and banana fruit by sun-drying and grinding into a meal. However, grinding makes it difficult for chickens to pick up feed if it almost becomes a powder. The results of other studies also show negative effects of using these processed carbohydrate feeds in a high percentage in the formulated diets. Gomez et al (1984) reported that on sun-drying, more than 86% of the HCN present in cassava was lost, probably due to the evaporation of free cyanide at about 28°C. However, using cassava root meal in poultry feed has a limitation because of its low protein content and deficiency of essential amino acids. Banday and Gowdh (1992) reported that broilers fed boiled cassava meal showed higher body weight gains than with raw cassava root, but the level of inclusion of this feed in the diet was not known. Eshiett and Ademosun (1980) reported that sun-dried cassava root meal could be included in broiler diets up 450 g/kg with no significant changes in growth performance, while Gomez et al (1983) reported that the performance of chickens on a control diet was similar to that of chickens fed up to 200 g/kg cassava root meal of cultivars low or high in cyanide content. Waldroup et al (1984) found out that replacement of one-third of the maize with cassava root meal had no adverse effects on body weight gains of broilers, but there was a reduction in weight gain at higher levels. Ravindran et al (1986) recommended that up to 15% cassava meal could substitute for coconut meal in broiler diets without affecting the growth performance.

Turner et al (1976) examined various diets containing cooked sweet potato as an energy supplement for poultry. Chicks fed on a starter feed reached slaughter weight sooner than when fed on sweet potato diets. Gerpacio et al (1978) studied the performance of two-week old birds fed rations containing sweet potato root meal replacing 0, 50, 75 and 100% of corn in the rations up to 6 weeks of age, and they reported that the performance of birds fed the sweet potato, and especially at the higher levels, was less satisfactory compared with corn, suggesting that the replacement with corn only up to 50% is advisable. This result is similar to Maphosa et al (2003), who reported that the inclusion of sweet potato had a negative effect on performance. There was a significant decline in weight gain of birds with increase in inclusion rate of sweet potato meal during the starter phase. There was a numerical decline in feed intake, although there was no significant difference up to 75% maize replacement rate. There was no difference in feed conversion of birds up to 50% maize replacement but it continued to deteriorate with increase in inclusion of sweet potato meal. Tewe (1994) reported that when sun-dried and oven-dried sweet potato replaced maize at 0, 50, and 100% in broiler rations, the performance was better with the oven-dried rations, and it could replace maize up to 50% in broiler rations, but performance was optimal at 30% replacement. However, Ayuk (2004) reported that sweet potato root meal could replace maize meal in the diet of broilers at up to 40 % with no effect on chicken weight gain.

The meal from whole banana fruit contains less anti-nutritional factors (Onibon et al 2007) and it would appear that a much higher level might be included in the diet of chickens. However, there was a negative effect on growth of feeding the diet of banana fruit meal with duckweed in the present study. Göhl (1981) stated that high levels of banana fruit meal tended to depress growth rate and reduce feed efficiency, and so it is recommended that not more than 10% of the grain portion of the poultry diet should be replaced by banana fruit meal. Sharrock (1996) also reported that banana fruit meal has been used in poultry diets, but high levels in the diet also tend to depress growth and reduce feed efficiency.

13. Conclusion

The results of the present study are not conclusive with respect to the effect of processing, and therefore further studies are required, focusing, in addition to processing techniques, on the effects of mineral supplementation or production system of the chickens.

14. Acknowledgements

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