DFID CROP POST HARVEST PROGRAMME AND LIVESTOCK PRODUCTION PROGRAMME

The use of oilseed cake from small-scale processing operations for inclusion in rations for peri-urban poultry and small-ruminant production

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FINAL TECHNICAL REPORT

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Contents

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Executive Summary

Poultry production is an integral part of Zimbabwe's small-scale farming sector that is practised by the majority of small-scale farmers. However the lack of adequate feed both in terms of quantity and quality is a major issue in this sector.

The aim of the project was to determine the benefits and constraints associated with the use of sunflower seed cake in maize-based poultry and goat diets. The project: (a) evaluated the market potential for the inclusion of sunflower ram-press oilcake in peri-urban and rural livestock feeds by poor farmers; (b) developed low cost fibre reduction methodology for application to sunflower oilcake; (c) evaluated the effect of the inclusion of sunflower seed cake in poultry diets on feed quality, feed intake, and poultry growth & development; (d) evaluated the performance characteristics of small-ruminant (goat) feeds, based upon sunflower oilcake; (e) evaluated the income generating potential of small-scale poultry production based upon sunflower oilcake; and (f) organised a field day for the dissemination of the project outputs.

The evaluation of the market potential for the inclusion of sunflower ram-press oilcake in livestock feeds was performed in Mashonaland Central Province (Guruve) and Mashonaland East Province (Mutoko).

The farmers interviewed clearly understood that, for a given breed of poultry, the major determinant of growth rate is accessibility to adequate, well-balanced feed supplies. However, normal practice involved the supplementation of indigenous poultry diets with poorly graded or spoiled grain, mainly maize. A few farmers used sunflower seeds and groundnuts. Consequently, the use of home-grown material as supplements in both indigenous and hybrid poultry production systems appeared to be an attractive, sustainable option, and many of the farmers interviewed appeared willing to grow additional grains and oilseeds. The study clearly showed that there was a resounding willingness in village women (the predominant poultry farmers) to introduce management systems that would increase the levels of production, consumption and income. They anticipated that with abundant feed resources, and an expected increase in flock size, the indigenous poultry produced would be equally used for home consumption and marketing. Poultry production was seen as generating more regular and reliable cash inflows.

The management if indigenous goats had continued to follow traditional systems of common pasture grazing and browsing, with very little dietary control. Goats also had access to crop residues during the dry season. Only a very small number of the farmers interviewed had fed their goats sunflower cake, partly because of the low availability of the cake, and partly because of a lack of knowledge of the potential advantages associated with supplementary feeding.

The marketing of indigenous poultry ($56.75 per kg, live-weight) had a much higher return than goat meat marketing ($11.60 per kg, live-weight). However, given the large cash injection associated with an occasional goat sale, those farmers interviewed perceived that the marketing of goats generated more income. The marketing of both poultry and goat meat reached a peak during the cotton marketing season (April to August) in Guruve, whereas the demand for goats was greatest during August to October in Mutuko. The consumption and marketing of goat milk was at an insignificant level.

It was considered that small-scale poultry production has the potential to enhance household incomes and food security as well as improve the nutritional status of the rural families. Small-scale poultry production can also be used as a tool for empowering the rural people especially women. However a number of institutional and socio-economic factors which still hinder the growth and development of small-scale poultry production in Zimbabwe were identified in the study. The factors include the farmers still perceiving poultry production as part of their livelihoods rather than as an enterprise, lack of prioritisation of small-scale poultry production research by government and researchers, lack of information/extension services in the communal areas and inaccessibility of markets.

Low-cost fibre-reduction methodology was developed that could be applied to sunflower oilcake. A sieving technique was developed, using a 1.4mm sieve, in order to separate the fibre. The fraction that passed through the sieve could be included in poultry rations, whereas the residual fraction was suitable for inclusion in small ruminant diets.

On-station poultry and goat studies were performed at Henderson Research Station in Mazowe Zimbabwe, whereas the on-farm poultry trials were performed at Mukodzongi in Chiweshe Communal Area, Mashonaland Central Province, Zimbabwe.

Two on-station studies were performed, comparing a) the performance of indigenous and commercial hybrid chickens and (b) the impact of a variety of diets on the performance of commercial hybrid chickens. The first on-station study utilised seventy day-old broiler chicks from each breed (indigenous and commercial hybrid). Weight gain and feed conversion ratio (FCR) were significantly lower in village chickens than in the hybrid birds. The latter were 78% heavier at 56 days of age with a mean FCR of 2.5 compared with 4.7 in village chickens. Village birds are generally kept on a free-range system, requiring minimal resource input, and as shown in this study, their limits of performance were rapidly reached when feeding and management were improved. However, they can supply local populations with additional income (Z$58.00 net profit per bird; return per dollar invested of Z$1.5) and meat that is high in protein (crude protein, CP, 73% dry matter) compared with the meat of hybrid chickens (CP, 68% dry matter). High mortality, especially during the brooder phase (0-21days) constitutes a greater constraint on village poultry production. It was considered that the formulation of low-input diets, utilising locally available feed resources, and crossing with selected varieties of birds, could improve the performance and profitability of village chickens.

In the second study, using commercial hybrid chickens, five experimental diets, diet 1 (0% sunflower substitution), diet 2 (10% substitution), diet 3 (20% substitution), diet 4 (30% substitution) and diet 5 (50% substitution) were evaluated, using one hundred and fifty day-old chicks. After the sunflower seed cake substitutions, the protein contents for diets 2 to 4 met the nutrient specifications for appropriate density feeds. Diet 1 was the control and diet 5 had a protein content below the specification. However at 56 days of age the average weight of the birds in the five treatments had attained the target weight of 2 kg. Although the weights at the end of 8 weeks were different for the 5 treatments, the differences were not statistically significant ($P>0.05$). All the five experimental diets had a crude fibre content below the maximum specification for poultry feeds. Directly substituting commercial feed concentrate with sunflower seed cake was found to have no significant effect ($P>0.05$) on feed intake by the broilers. The substitutions were able to reduce the feed costs of producing each kilogram of live weight by up to 17% whilst production remained profitable with a farmer having the potential of making at least Z$1.58 for each dollar invested in poultry production. As a result of this second study, it was considered that sunflower seed cake had the potential of being used as a partial replacement for commercial poultry feed concentrate, in order to reduce costs without greatly affecting the nutrient quality of the feed, the growth performance of the birds and profitability of the enterprise.

Consequently, an on-farm study was conducted on ten household farms, using groups of hybrid and indigenous birds kept under both penned and free-range conditions. The starter feed was a commercial broiler starter mash, whilst the finisher diet consisted of thirty per cent low-fibre sunflower residue together with broiler concentrate and maize meal. The meat from village chickens was higher in protein and lower in fat than hybrid chickens. After twelve weeks, the return per dollar of free-range village chickens was high (1.55) and similar to free-range hybrid birds (1.60). However, the return per dollar was highest for penned hybrid birds (1.80) and lowest for penned indigenous chickens.

The use of ram-pressed sunflower cake was also evaluated as a supplement to kapeters (male castrate goats) subsisting on a low basal diet of maize stover, groundnut tops and sunflower heads. The performance of the goats was compromised by the presence of excess fat in the diets, most probably originating from residual seeds in the sunflower heads and from residual fat in the sunflower cake. It was concluded that the efficiency of oil extraction in the ram-press needs to be significantly improved if sunflower cake is to be successfully exploited in small ruminant diets.

The results of the on-farm poultry feeding study were successfully disseminated, by the female farmers, at a field day attended by some six hundred farmers.

Background

Sunflower seed, *(Helianthus annuus)*, is a crop widely grown in many parts of Zimbabwe by smallholder farmers as a cash crop. On average it is estimated that 60% of small-scale farmers grow sunflower purely as a cash crop whilst the remaining 40% grow the crop for both cash and domestic use (Chiduza 1995). Sunflower is popular with small-scale communal farmers because it is an easy crop to produce. It requires very limited inputs both in terms of labour and cash (Hikwa and Malusalila 1992, Chiduza 1995 and Sukume *et al.* 2000). In many areas of Zimbabwe, sunflower is now taking up land, which would have been left fallow due to a lack of farming inputs. The general practice is to plant sunflower and leave it to grow on its own with little inputs and weeding. Sunflower is known to be an efficient user of residual fertiliser because of its extensive root system (Chiduza 1995). Therefore the crop does well in a rotation following a well-fertilised crop. Thus regardless of yield, sunflower will be competitive in most small-scale communal farming areas (Sukume *et al.* 2000). Another factor favouring sunflower is its drought tolerance. This makes it suitable for growing in the marginal/low rainfall areas such as natural regions IV and V where most of the communal areas are to be found.

Demand for vegetable oil in Zimbabwe exceeds output from the commercial processing industry. This has led to poor nutrition, especially of children and nursing mothers in the resource poor rural areas, that is linked to a lack of fat in people's diets. As a result of this, the Government of Zimbabwe in the late 1980s, in line with its policy of self-reliance and rural development called for an increase in oilseed production and processing in the rural areas. Government and Non-governmental Organisations felt that vegetable oil production in the rural areas was a very viable vehicle for development since besides the oil being a scarce commodity, it also has a high nutritive value as cooking oil and a potential for generating additional income for the farmers (Nazare, Ngere and Henrickson 1991a and 1991b). This was based on the belief that introducing small-scale oilseed processing equipment, such as ram presses, in the rural areas would help reduce the need for cash to buy oil whilst at the same time also improving the nutritional levels of the people by supplying the necessary dietary fat. Oil production was also found to have the potential to increase farmers' incomes and to create employment for farmers and ram press operators (IDRC 1998 and Schmidt 1999). In fact work carried out by the International Development Research Centre (IDRC) of Canada, in Eastern and Southern Africa in 1998, found out that on average local farmers who were also involved in small-scale oilseed processing can earn two to three times more gross income, as compared to selling their oilseed to large processing companies or marketing boards. The ram press, which is used by the majority of small-scale oilseed processors in Zimbabwe, works by applying pressure on seed inside a cylinder and cage by means of a piston. Under pressure, the seed releases oil that flows out through gaps in the cage, and the cake is forced out of the other end past a restrictor (Nazare and Nalumansi 1996). By 2001, four thousand ram presses had been sold countrywide in Zimbabwe since their introduction in 1986 (Bachmann 2001).

Chickens must be given balanced feeding in order to keep them healthy and allow them to attain maximum production. Commercial broiler producers try to maximise profit by having a rapid turnover and maximum production levels, with the use of high-nutrient-density specification feeds, which make maximum use of the genetic potential of the stock. These commercial feeds are formulated using cereals and high quality protein sources such as soya bean meal and fishmeal, which are imported or obtained locally. By contrast the small-scale farmers cannot afford these high-nutrient-density specification diets. In order for them to maximise the productivity of their poultry, it is necessary to come up with formulations that make maximum use of locally available raw materials whilst at the same time giving an acceptable performance from the poultry.

The project specifically evaluated the potential of using the by-product of oil expression using a ram press, sunflower seed cake, in poultry feeds. Normally the utilisation of sunflower seed and its by-products in poultry feeds is limited because of its relatively high fibre and low lysine content as compared to other oilseeds, especially soyabean (McGinnis *et al*. 1948, Jacob *et al*. 1996 and San Juan and Villamide 2000). Because of this, when the sunflower seed cake is fed to poultry in large amounts, supplementary lysine and a rich source of energy have to be added (Gohl 1981). Sunflower seed cakes also tend to be hard and therefore are best-fed ground and incorporated into compound feeds (Gohl 1981). However, communal farmers in Zimbabwe feed sunflower to their poultry as either whole seed, sunflower seed cake or as a mixture of crushed whole sunflower seed in a mixture with crushed maize. Feeding rates are not fixed, with a lot of farmers providing feed on an *ad-lib* basis. As a result, birds fed on sunflower whole seed or sunflower seed cakes tend to be over fat, easily succumb to diseases and can die of exhaustion (Hanyani-Mlambo 1999).

The potential for utilising ram press–produced oilcake in livestock diets is largely un-researched. A variety of NGOs, agricultural extension workers and other individuals have urgently requested information on the utilisation of this material. Poultry broiler rearing is increasing in popularity amongst peri-urban dwellers, but the high cost of commercial feedstuffs is a frequently voiced constraint.

The research outputs from the project will benefit small-scale oilseed processors, small-scale poultry and ruminant producers, and poultry and small-scale ruminant consumers.

Project Purpose

Project purpose: strategies developed and promoted for increased availability and improved quality of crop and livelihood products

The project generated knowledge that will enable oilseed processors and poultry & small ruminant producers to make informed decisions on the utilisation of ram press-produced sunflower oilcake in livestock diets.

Research Activities

The research activities were as follows:

1.1 Socioeconomic survey of the production of rurally processed sunflower cake, and scale and types of poultry and small-ruminant production in peri-urban and rural regions growing sunflower

This activity was performed using a small multidisciplinary team composed of the principal researcher (a socio-economist), two field enumerators, one poultry specialist and two small ruminant research officers from DR & SS. Data were collected by questioning farmers in Lower Guruve District (Mashonaland Central Province) and Mutoko District (Mashonaland East Province); and by performing an extensive desk study.

2.1 Development of simple technologies (based on sieving, air classification and density) for reducing fibre level (and any associated anti-nutrients) in sunflower and sesame oilcakes prepared by small-scale processing

Production of sunflower oilcake

The sunflower seed was purchased from local agricultural merchants, (Gillet Cook Ltd), and was typical of the type normally used for the production of sunflower oil in Zimbabwe. A hand operated Bienlenberg-type ram press was used to expel the oil from the whole seed. Here, a reciprocating piston delivers the seed to the compression chamber, where it is compressed by the same piston at a very high pressure. After compression, the liberated oil escapes from the chamber. The defatted seed (oilcake) is then forced out of the chamber against an adjustable cone that restricts the flow of cake and maintains pressure within the chamber.

Sieving procedure

The sunflower oilcake was sieved using 1.0, 1.4 and 2.0 mm test sieves (30 cm diameter equivalent to an area of 706.86 cm^2) using the following procedure:

1. Obtain a representative sample (ca. 1.5 kg) of sunflower cake by coning and quartering the cake produced by the ram press

2. Rub the representative sample of sunflower seed cake between hands for 1 min., in order to loosen the fibre

3. Fit sieve receiver to each sieve, and tare

4. Weigh 150g of 'rubbed' cake into sieve

5. Sieve the cake as follows:

    - Sieve cake for 30 secs.
    - Rub cake on sieve mesh for 30 secs.
    - Sieve cake for 30 secs.
    - Rub cake on sieve mesh for 15 secs.
    - Sieve cake for 15 secs.
    - Weigh and record contents of receiver
    - Weigh and record contents of sieve

6. Send sample of whole sunflower seed, rubbed cake, sieve and sieve receiver for proximate analysis

Further sieving experiments were also conducted using a locally produced 1.4mm sieve

3.1 Evaluate, in collaboration with NGOs within Zimbabwe, the extent, quality, quantity and price of locally available ingredients capable of being included into diets for poultry feeding. Visits will be made to several small-scale oilseed processing units to obtain a range of samples of oilseeds being processed. During this visit those poultry

producers willing to be involved and demonstrating the capacity to collaborate in later poultry feeding trials will be identified.

Data on the price and availability of locally-available feed ingredients were collected during socio-economic evaluations performed in the field, during the performance of poultry feeding studies, and during an extensive desk study.

3.2 Analyse samples of oilseed cake and other ingredients for nutritional and anti-nutritional quality

A variety of analyses were performed including proximate analysis (moisture content, oil content, crude protein, crude fibre, ash, carbohydrates), amino acids, metabolisable energy (ME) calcium, phosphorus, and *in-vitro* digestibility.

3.3 Formulation of broiler diets according to the results of the analysis and price of ingredients

Two studies were conducted to: (a) compare the on-station performance of village (indigenous) chickens, under improved feed management, with the performance of hybrid chickens; and, (b) study the on-station performance of commercial hybrid broilers when fed a variety of diets containing sunflower oilcake.

The details of the formulations utilised in these studies are given in Activity 3.4, below.

3.4 Conduct broiler trials at Henderson Research Station, Zimbabwe, using both hybrid and cross-bred chicks. (Trials based on five treatments x 3 replicates x 15 birds per treatment)

A comparison of the on-station performance of village (indigenous) chickens, under improved feed management, with the performance of hybrid chickens

Introduction
Village or indigenous chickens *(Gallus gallus domesticus*) are the most common types of poultry raised in the rural areas of Zimbabwe. Approximately 80 percent of poultry in Africa are raised in rural areas where they contribute substantially to egg and meat production (Sonaiya, 1997). In general village producers keep small flocks of between 5 to 20 birds per household (Gueye, 1997).

Village chickens are generally raised on a free-range system where they survive as scavengers. They are maintained with low land, labour and capital costs, resulting in almost every household and the poorest social strata of the rural population keeping them.

Based on low inputs and outputs, village chicken production represents an important part of a balanced farming system with a unique role in the economy of the rural household. They are a source of high quality protein for the family, provide a small income and play a part in the cultural life of the society. Reports in literature have revealed that indigenous chickens take long to reach maturity and lay fewer clutches of eggs per year compared to modern breeds (Safalaoh, 1997). There is limited information on the meat potential of village chickens and their performance under improved feeding management has not been fully characterised in Zimbabwe.

The objective of the current study was to evaluate the potential of village chickens for meat when given an improved feeding management system commonly used with hybrid birds; and to evaluate the economic returns of keeping village chickens and hybrid birds.

Experimental Design and Poultry

The experiment was carried out from January to March. A total of one hundred and fifty 1 to 7 day old eggs were collected from village chickens in Zimbabwe. The eggs weighing 23 ± 1.6 g SD were kept at room temperature for 24 hours and transferred to the incubator. The manufacturer's recommendation for the operation of the incubator was followed. At the 18th day of incubation the eggs were transferred to hatching trays. The chicks started to hatch during the 18th hour of the 21st day of incubation. Eighty chicks were hatched by the 23rd day of incubation. The 23rd day of incubation coincided with the arrival of day old hybrid chicks from Irvine Day Old (Pvt) Ltd. which produces 80 percent of commercial hybrid chicks for the poultry producers in Zimbabwe. Seventy-day-old hybrid chicks (41 ± 2 g SD average body weight) and 70 village chicks (40 ± 1.5 g SD average body weight) were transferred to the floor pens in a deep litter where they were raised under similar conditions.

Housing and Management

The birds were housed in a deep litter shed made from concrete blocks with asbestos roof. The shed was partitioned into two blocks of 20 pens. The pens measuring 15.0 m^2 were partitioned further to 4 m^2 using round cardboard boxes during the first 5 weeks of the experiment. The chicks were divided into groups of 7 birds per group and randomly assigned to 20 pens in a complete randomized block design with 10 pens per treatment.

The mean house temperature was 24.4^o C ± 3.42, with temperature ranges of 18-21, 23-32 and 22-30^{o}C in the morning, at noon, and in the evening, respectively. The relative humidity ranged from 58.3% at noon to 84% in the early morning. During the 21 day brooder phase, natural light was used in the day time, with infra red light from electrical bulbs at night, to maintain a total of 24 h light each day.

Tubular metal hoppers 40 cm in diameter carrying 10 kg of feed were used as feeders. Round plastic basins, 15 cm deep and 25 cm diameter, were filled with clean water, daily, in the morning. Feed troughs were cleaned and filled with feed once per week during weighing.

Diets

Broiler starter feed and water were supplied *ad libitum* to both hybrid and village chickens during the brooder phase up to 28 days. Finisher diet was provided up to 56 days. The feed was formulated to meet the nutritional requirements for poultry as recommended by the Agricultural Research Council (ARC) (1975). The broiler starter feed mixture comprised broiler concentrate and maize meal in a ratio of 1:1.5 respectively, while the finisher diet consisted of a 1:1.8 mixture of broiler concentrate and maize meal. The broiler concentrate supplied by Agrifoods (Pvt) Ltd was balanced for minerals and vitamins and consisted of 90 percent Soya bean meal. The maize meal was a product of yellow maize grain, ground to pass through a 1mm screen. The feed was mechanically mixed at the beginning of the experiment using a horizontal feed mixer (Bentil Engineering (Pvt) Ltd)

Measurements

Daily intake of feed and water were recorded as means of the group by difference of feed offered and feed remaining in the feed hopper, and water offered and water left. Daily temperature and relative humidity were recorded in the morning at 0600h, at noon and in the evening at 1800h. The carcass composition of village and hybrid birds was analysed at the end of the experiment from a sample of representative birds. In addition, the proportion of hatched village eggs was calculated.

Ten chickens from each of the treatments were slaughtered at 9 weeks of age to study the proportions of body components such as dressing percentage, lean, bone, head and neck, heart, lungs, wings, thighs and legs, feet, liver, stomach and crop, length of digestive tract and caecae

Chemical analysis
Feed samples were analysed for dry matter (DM), crude protein (N x 6.25), crude fibre (CF), ether extract, ash, calcium and phosphorus by standard AOAC methods (AOAC, 1990). Metabolisable contents of the diets were calculated from the chemical analysis data using the equation:

$$ME\ (kcal/kg) = 4.26X_1 + 9.5X_2 + 4.23X_3 + 4.23X_4$$

The calculated digestible crude protein, fat, fibre and nitrogen free extractives (g/kg feed) are represented by X_1 through X_4

Statistical analysis
Data on various parameters were subjected to statistical analysis using analysis of variance (ANOVA); General Linear Model procedure of GENSTAT 5 Release 3.2 statistical software.

Economic analyses
Economic analyses were carried out using current feed prices in the Zimbabwe Poultry industry to compare the feeding costs, when feeding village chickens and hybrid chickens, in relation to meat production.

The on-station performance of commercial hybrid broilers when fed a variety of diets containing sunflower oilcake

Introduction
The on-station trial involved the direct substitution of commercial broiler concentrate, which is expensive to buy, with the relatively inexpensive ram press sunflower seed cake in maize based broiler finisher diet. The aim of the trial besides the reduction in the total cost of the poultry feed was to determine the effect of the substitution on the feed consumption patterns, growth and development of the birds. This was achieved by determining feed intake daily and birds' masses on a weekly basis. The broiler concentrate bought from Agrifoods (Pvt) Ltd is balanced for minerals and vitamins and consists of 90% Soya bean meal with no maize included. The substitution rates of sunflower seed cake for commercial concentrate varied between 0% and 50%, whilst the proportion of maize in the diets was kept constant.

Facilities
The on-station trials were conducted over an eight-week period starting in December 2000 up to February 20001, using facilities of the poultry section of Henderson Research Station in Mazowe, Zimbabwe. The mean poultry house temperature during the trials was $24.4^{o}C \pm 3.42$ sd with a range of maximum temperature of $32^{o}C$ and minimum temperature of $18^{o}C$. Relative humidity ranged from a minimum of 58.3% to a maximum of 84%.

Diets
The experimental plan consisted of five treatments with two replications each. The experimental design was a Randomised Complete Block with 2 pens x 15 birds per pen for each of the five treatments. This experimental design enables better replication within and between replications. The experimental diets consisted of commercial concentrate purchased from Agrifoods (Pvt) Ltd, white maize grown at Henderson Research Station and sunflower seed cake from the rampress oil extraction project at Henderson. The oil was extracted over a period of time and stored in bags until the time of the trial. This could have had an effect on the quality of the seedcake as it was from different extractions. No tests were carried out to ensure uniformity. The sunflower seed cake was included in the diets without sieving or grinding as is done in the rural areas. Giving the seedcake in this way also allows the birds to self select what they take in and refuse whatever is too coarse for them. The sunflower seed cake was thus coarse in texture. The maize was ground in a hammer mill to pass through a number 1 screen. Samples from the five diets were taken to the chemical analysis laboratory at Henderson Research Station were they were analysed by the resident feed analyst. The diets were analysed in triplicate for dry matter, ash, crude protein (N x 6.25), crude fibre, ether extract, calcium and phosphorous by standard AOAC methods (AOAC, 1998). The birds were given a standard starter diet consisting of commercial concentrate and white maize mixed in a ratio of 2:3 from 0 to 3 weeks of age. From 4 to 8 weeks of age the birds were given the five experimental diets.

The diets were mixed weekly on the floor using shovels. This method was chosen, as it is the most practical way in which mixing can be done in the rural areas.

Data Collection
One hundred and fifty day-old broiler chicks were obtained from Irvine Day Old Chickens (Pvt) Ltd. As stated before, broilers were chosen for the trials because of their standardised metabolism and growth characteristics. The birds randomly were distributed into ten floor pens of fifteen chickens each. The pens were in two blocks of five pens each. Each floor pen measured 3m x 5m in size with dry grass for litter (deep litter system). The pens were further partitioned to $4m^2$ using round cardboard boxes during the first 4 weeks of the trial for brooding purposes. Heat was provided during the brooding period using suspended infrared lamps. The appropriate height of the lamps was determined by observing the behaviour of the chicks.

When the lamp was too high the birds felt cold and huddled together under the lamp. When the lamp was too low, the birds felt hot and moved away from the lamp. The appropriate height was determined as the height at which the chicks were evenly distributed within the brooder. After four weeks, the cardboard boxes were removed and the chickens in the pens in each block were randomly assigned one of the diets so that each dietary treatment had two replications, one in each block. Feed and water were provided *ad libitum* for the 8-week trial. The chicks were placed in cages and weighed on a pen basis at the start of the trial and at the end of each week. Feed consumption was determined on a daily basis as being the mean of each group by measuring the difference in weight between the feed offered and feed remaining in the feed trough. The temperature and relative humidity were recorded daily in the morning at 0600 hours, at noon 1200 hours and in the evening at 1800 hours. Mortality was recorded as it occurred. The data obtained during the trials was statistically analysed using Analysis of Variance (ANOVA) General Linear Model procedure from Genstat 5 Release 3.2 Statistical Software for Windows.

References

Please see references under Output 3.

4.1 Determination of the nutrient analysis and in-vitro digestibility of all diet components for goat feeding trial

See below, paragraph 4.3

4.2 Formulation of diets according to results of analysis

See below, paragraph 4.3

4.3 Conduct goat trials at Henderson Research Station (Trials based on 4 treatments x 2 replicates x 5 animals per treatment)

On-station goat feeding study

Introduction
Expansion of peri-urban goat production in Zimbabwe is being hampered by a shortage of readily available feed resource both in quantity and quality, particularly in the dry season. In tropical and sub-tropical regions, the feed available for ruminants in the dry season is deficient in nitrogen, digestible energy and elements such as phosphorus, sodium, calcium, zinc, iodine and cobalt (Minson, 1982). These dietary deficiencies need to be corrected to enhance animal production.

Production of oilseeds, particularly sunflower in Zimbabwe's smallholder sector is significant and rural oil processing is being promoted. The by-product, sunflower cake (SFC) is potentially a good animal feed. It has both good protein content and energy in the form of fat (Mupeta, Weisberg, Hvelplund and Madsen, 1997).

The feeding of fats has been reviewed by Palmquist and Jenkins (1980), Storry (1981), Palmquist (1984). Incorporating additional fat in the diet offers several opportunities for improving the efficiency of energy utilization. Firstly the high energy density of fat may allow increased energy consumption and performance where energy intake is limiting. Secondly, increased fat availability from the diet may increase net efficiency of product synthesis. Thirdly, direct transfer of dietary fat to tissue would result in a partial efficiency of product synthesis. The fourth opportunity lies in the potential of substituting fat for rapidly fermentable carbohydrate in the diet fed to highly productive ruminant animals, thereby increasing forage fibre in relation to total dietary carbohydrate, improving rumen fermentation and fibre digestion and consequently tissue fat synthesis. In growing ruminant animals, the fifth advantage is the fact that fat may decrease the requirement for glucose and spare amino acids from breakdown for gluconeogenesis.

This study was conducted to evaluate the growth performance of growing kapeters offered a basal diet of maize stover mixed with sunflower heads and groundnut tops, and supplemented with SFC.

Facilities
The study was conducted at Henderson Research Station (HRS), Mazowe, Zimbabwe. The station is situated at 17°35´ South and 30°58´ East. The altitude is 1 290 m above sea level at the floor of the valley rising to 1 540 m on the hills. HRS has a subtropical summer rainfall

climate with the main rains starting in mid- to late-November and ending late in March or early April. The 45-year mean annual rainfall is 875.2 mm. The mean maximum temperature is 26.3°C and the mean minimum temperature is 10.4°C.

Animals and Housing
Twenty-four small east African male castrate goats (kapeters) (14.62 ± 3.321 kg) from the station flock were used. All kapeters were dosed with Tramisan (levamisole hydrochloride 2.5 % m/v and oxyclozanide 3.4 % m/v) and vaccinated with Heptavac (activates immunity against diseases caused by Clostridium species) as a prophylactic measure just before the start of the experiment.

The kapeters were confined in individual pens measuring 1.8 x 1.2 m and with sides of 1.3 m height stretching the length of the pen on both sides. Feed and water troughs were on the front end of the pen and a wire mesh enclosed the back end. No bedding was provided. Accumulated manure was removed once a week.

Diets
A basal diet consisting of 60 per cent maize stover, 30 per cent groundnut tops and 10 per cent sunflower heads was formulated. A vitamin mineral premix was included in the basal diet at 0.1 per cent. All stover ingredients were milled through a 25 mm screen sieve. Ram pressed Sunflower cake was offered as the supplement at four different levels: 0, 15, 30 and 45 g/kg$^{0.75}$/d.

Experimental Design
The kapeters were ranked according to live weight. They were divided into four groups allowing for bodyweight, giving six animals per treatment. These groups were randomly allocated to the four different treatments. The design was a randomized complete block with weight being used as the blocking factor.

Feeding and Management
The animals were offered the basal diet and the supplements separately. The weights were measured on air-dry basis. Sunflower cake was offered at 0, 15, 30 and 45 g/kg$^{0.75}$/d with the amounts calculated weekly after weighing. The basal diet was offered at 1.5 times the previous day's intake. Feed refusals were weighed daily. Live weight was measured every week throughout the experiment. Starved live weight was measured at the beginning and end o the experiment. Starving was effected by depriving the animals of feed for 24 hours and water for 12 hours. Starved weights were the basis for calculating live weight change. The experiment was conducted for 56 days.

Chemical analysis
Analyses of dry matter, ash nitrogen and ether extract were carried out according to AOAC (1984) procedures. Neutral detergent fibre was determined according to Van Soest, Robertson and Lewis (1991).

Statistical Analysis
Body weight data were analysed as a randomized complete block with initial body weight as a covariate according to the model:

$$Y_{ijk} = \mu + B_i + T_j + \beta * T_{ijk} + e_{ijk}$$

while the rest of the data were analysed as a randomised complete block design using the model:

$$Y_{ijk} = \mu + B_i + T_j + e_{ijk}$$

In both models Y_{ijk} is the response of lamb k in block i and treatment j; μ = general mean; B_i = fixed effect of block; T_j = fixed effect of treatment; β = regression coefficient of the covariate; T_{ijk}= the pretreatment average value (covariate) and e_{ijk} = the residual variation. Least squares means were computed and the differences between means were assessed using the PDIFF option in GLM procedures (SAS, 1996).

References
See references under Output 4

4.4. Attend LPP stakeholders meeting at Matopos (September 2000) to present work plan and achievements to date

5.1 Replication of feeding trials which demonstrated optimal results under controlled conditions, by village level small-scale poultry and goat producers

On-farm (village level) poultry studies

The prevailing security conditions in Zimbabwe prevented the implementation of village level (on-farm) feeding trials by goat producers. However, an on-farm poultry feeding trial was conducted, as follows:

Introduction
The high cost and limited supply of commercial feeds is a major factor limiting production and expansion of the poultry in the smallholder-farming sector in Zimbabwe. As a result, the demand for alternative low-cost livestock feeds is soaring. Studies performed with crossbred dairy cows showed that ram press SFR was a viable option for low-cost dairy diets, if the sunflower is grown with oil extracted at home and the residue used in livestock feed rations (Mupeta, 1999).

Commercial poultry diets rely on soyabean to supply the major portion of dietary protein requirements. Therefore, soyabean meal is generally considered as the standard protein supplement in poultry diets in many parts of the world (Ravindran and Blair, 1992). While soyabean is not easily available among the smallholder farmers in Zimbabwe, sunflower (*Helianthus annus*) is widely grown as a cash crop. It can easily thrive in sandy-loam soil with low organic matter, receiving low rainfall and high temperatures. The smallholder farmers produce about 90 percent of the sunflower delivered to the Grain Marketing Board[1] (GMB) in Zimbabwe (Hikwa and Whingwiri, 1986).

Compared with soyabean, sunflower is rich in sulphur amio acids, cystine and methionine but lower in lysine. However, the utilization of sunflower in poultry production is limited by high fibre content (Smith, 1968). The high fibre and associated polyphenolic compounds (chlorogenic acid), found in sunflower hulls are reported to limit intake and digestibility and may cause adverse effects on poultry performance (Singleton and Kratzer, 1969). Mupeta *et al.*(2001) demonstrated a simple sieving device consisting of passing sunflower residue

[1] GMB - a parastatal with monopoly to buy and sell grain and oilseeds from farmers in Zimbabwe.

through 1.4 mm screen and produced low-fibre SFR with a high protein fraction. There is a double benefit in reducing the fibre fraction since chlorogenic acid is found in association with the sunflower seed hull (Luhaloo, 1996).

The potential role of low-fibre sunflower residue in poultry diets and the performance of hybrid and village chickens raised in pens and on the free-range has not been evaluated on-farm. Therefore, the objective of the present study was to evaluate the utilization of low-fibre sunflower residue diet on the performance of hybrid and village chickens, raised in pens and on the free-range and managed by farmers at their homesteads.

Facilities

The experiment was carried out at 10 household farms in Chiweshe smallholder farming area in Zimbabwe during early summer. Three hundred and fifty (1-7 day-old) eggs were collected from village chickens in Chiweshe district. The eggs weighing 23 ± 1.6 g sd were kept at room temperature for 24 hours and transferred to the incubator at the University of Zimbabwe. The manufacturer's instructions for the operation of the incubator were followed. At the 18th day of incubation the eggs were transferred to hatching trays. Hatching started during the 18th hour of the 21st day of incubation. Two hundred and thirty chicks were hatched by the 23rd day of incubation (66% hatchability). The 23rd day coincided with the arrival of 228 day-old hybrid chicks from Irvine Day[2] (Pvt) Ltd. Two hundred hybrid chicks (42 ± 2 g sd) and 200 village chicks (38 ± 1.5 g sd) were divided into 16 groups of 25 chicks and transferred to 16 brooder boxes where they were reared under similar conditions (1-28 days). The surplus chicks were raised under similar treatment in order to provide replacement chicks during brooding (1-28 days).

Housing and Management

The chicks were reared in16 brooder boxes (1-28 days). The brooder boxes, each measuring 6 m^2 were made of plywood with floors of mesh wire and raised 20 centimetres above ground. The boxes were housed in a thatched house with mean temperature of 23.3^0 C ± 4.21 sd. Temperature ranged 19-22^{o}C, 25-33^{o}C and 22-32^{o}C mornings, noon, and evenings respectively. Natural light was used in the daytime, with no supplementary lighting at night during brooding. On day 29 of the trial, the chicks were randomly divided according to breed into 40 groups of 10 birds per group and allocated to 4 treatments, which were replicated on 10 farms and managed by women-households in a complete randomized block design. The treatments included hybrid chicks in pens, hybrid chicks on free range[3], village[4] chicks in pens and village chicks on free range.

Diets

Broiler starter feed and water were supplied *ad libitum* to both hybrid and village chicks during the brooder phase (1- 28 days). Low-fibre SFR[5] diet was offered *ad libitum* to hybrid

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[2] Irvine Day - a poultry breeding and hatching company, producing 80% of hybrid chicks in Zimbabwe.

[3] Free-range – chickens are not confined in pen, they are allowed to scavenge for food around the home

[4] Village chicken – indigenous chicken/poultry found at villages in rural areas in Zimbabwe

[5] SFR sunflower residue fraction with reduced fibre and increased protein due to sieving

and village chickens raised in pens (29-84 days), while those on the free-range were offered 75% of the weekly intake of chickens on *ad libitum* plane of nutrition. The feed was formulated to meet the nutritional requirements for poultry as recommended by the Agricultural Research Council (ARC) (1975). The starter feed comprised of a commercial broiler starter mash with 21% crude protein, supplied by Agrifoods feed manufacturing company. The finisher diet consisted of 30 percent low-fibre sunflower residue, in the ratio 1: 1.36: 2.18 (broiler concentrate, low-fibre sunflower residue and maize meal respectively). Broiler concentrate was balanced for minerals and vitamins and contained 90% Soya bean meal. The low-fibre SFR was a by-product of home grown sunflower seed, whose oil was extracted using ram press machine. About 2 500 kg of sunflower seed (variety, PAN 7353) was compressed using a manually operated ram press machine to yield 600 kg of oil and 1800 kg of sunflower residue. The sunflower residue was passed through a sieve, 1.4 mm screen to recover a low-fibre, high protein fraction and retain a high fibre, low protein fraction. The low-fibre SFR was used as a protein concentrate in poultry diet. The maize meal was a product of white maize grain, milled to pass through a 1.0 mm screen using a hammer mill (Dulys Engineering (PVT) Ltd). All feed was mixed in bulk to ensure uniformity. Mixing was done on a concrete floor using shovels, after which the feed was distributed to the participating farmers in the experiment.

Tubular metal hoppers 40 cm in diameter carrying 10 kg of feed were used as feeders. Round plastic basins, 15 cm deep and 25 cm diameter, were filled with clean water, daily, in the morning. Feed troughs were cleaned and filled with feed once per week during weighing.

Measurements

Chickens were weighed weekly on the same day and time of the week using a hanging balance scale, daily feed intake was recorded as the difference of feed offered and feed remaining in the feed hopper, and daily water intake as the difference of water offered and water left. Daily temperatures were recorded in the morning at 0600h, at noon and evening at 1800h. The carcass composition was analysed at 8 and 12 weeks from a sample of representative birds. Two chickens from each of the treatments were slaughtered at 8 and 12 weeks to measure dressing percentage, lean, bone, protein and fat value of meat. Profitability was calculated using prevailing variable input costs and the revenue from sale of chickens at 8 and 12 weeks

Chemical analysis

Samples of the experimental diets were analysed according to the methods of the Association of Official Analytical Chemists (1990; Table 1). Analysis was conducted for dry matter (DM), crude protein (CP; N x 6.25), crude fibre (CF), ether extract (EE), calcium and phosphorus. Metabolisable contents of the diets were calculated from the chemical analysis data using the equation:

$$ME\ (kcal/kg) = 4.26X_1 + 9.5X_2 + 4.23X_3 + 4.23X_4$$

The calculated digestible crude protein, fat, fibre and nitrogen free extractives (g/kg feed) are represented by X_1 through X_4

Statistical analysis

Data on various parameters of broiler performance were subjected to statistical analysis using analysis of variance (ANOVA); General Linear Model procedure of GENSTAT 5 Release3.2 statistical software.

References
See references under Output 5.

5.2 Economic viability study of broiler and goat production based on sunflower and sesame oilcakes under village production systems

The profitability of feeding diets containing low-fibre, sunflower oilcake to hybrid and village chickens was calculated during the on-farm study (paragraph 5.1, above) by recording gross income, total variable costs and gross margin, and using these data to compute the return per dollar invested.

6.1 An international, end of project workshop will be held to disseminate results and provide a forum for information exchange and to present recommendations for research uptake. Stakeholders identified at the LPP Matopos meeting (see Activity 4.4) are to be invited

The prevailing security conditions in Zimbabwe have militated against an international project workshop. However, a successful field day was held, after the on-farm poultry feeding study, that was attended by some six hundred farmers.

Outputs

Output 1: Knowledge of the market potential for the inclusion of sunflower ram-press oilcake in peri-urban and rural livestock feeds by poor farmers

Management of poultry in the small-scale farming sector in Zimbabwe like in other African countries is associated with women. Poultry production in most cases is the main resource where women farmers have more access to benefits accrued (Kitalyi 1999 and Kusina 1999). However, a number of constraints most of them gender-based affect the expansion and development of poultry production in the smallholder-farming sector.

There is generally a poor access to information on poultry production in the smallholder-farming sector. This is because there has been no progress in the development of smallholder poultry production; instead most livestock development has been targeted on cattle for draft power, beef production and small-scale milk production (Kusina and Mhlanga 2000). Government extension agencies in the rural areas of Zimbabwe include the Department of Agricultural, Technical and Extension Services (AGRITEX) and the Department of Veterinary Services. The Department of AGRITEX is responsible for provision of assistance in poultry management and production issues whilst the veterinary extension assistants are responsible for disease investigations and provision of advice to farmers on disease prevention and control. There is evidence that the research and extension services in Zimbabwe do not cater adequately, either for women producers, who are the primary stakeholders or for the system of smallholder poultry as a whole (Kusina 1999 and Oakley 1999). Although, these services can potentially provide support to smallholder farmers, there is a need for sensitisation and prioritisation of poultry production issues among their activities as presently there is lack of expertise in issues of poultry production (Kusina and Mhlanga 2000). As stated before, most of the poultry farmers are women and a majority of the extension workers is male. Zimbabwean women are traditionally reserved when dealing with men or a stranger, which makes it difficult for them to gain full access to any information that may be available. At the same time the extension services are not able to reach most of the smallholder farmers due to lack of adequate resources and staffing. A survey carried out in

Zimbabwe on behalf of FAO, showed that about 78% of the smallholder poultry producers surveyed claimed to have no support or contact with the formal veterinary and extension services (Oakley 1999).

Improved poultry production has the potential to contribute to development and improve food security in the rural areas (Tadelle and Ogle 1996, Kusina and Mhlanga 2000). Improved food security and cash inflow of the community through the efforts of women reduces their dependency on men thus empowering them and helps in the alleviation of hunger and poverty. However, experience has shown that men tend to sabotage 'women's' projects when they start being successful and the men feel left out (Kusina and Mhlanga 2000). Therefore men have to be involved in the poultry production at some level although in order for them to be cooperative they have to be trained to be gender sensitive. A survey carried out in Zimbabwe (Kitalyi 1999), showed that women dominate most poultry production activities except shelter construction and marketing, which are usually reserved for men.

Another factor that is likely to affect the development of smallholder poultry production is that of labour. Labour is a problem in the rural areas of Zimbabwe, it is either not available due to the rural urban migration or where it is available it is under-utilised (Hanyani-Mlambo 2002). Since farming is considered in most cases as a way of life rather than an enterprise, the small-scale farmers have other duties to attend to besides farming. Farmers also observe traditional rest periods in the dry season such as *chisi* where no work can be carried out (Hanyani-Mlambo 2002). Women who are responsible for poultry management already carry heavy workloads in the smallholder-farming sector and changes in poultry management that result in increased labour requirements might face obstacles (Rushton and Ngongi 1998). Poultry production is seen as only one of the many household and farm activities that women have to carry out and is rarely a priority concern even for the women themselves who tend to value it more than men (Oakley 1999). Other activities such as household duties and seasonal crop-related work usually take precedence over poultry activities. Therefore rural women with a full daily schedule might not be able or willing to increase their workload by putting in extra effort into poultry management (Rushton and Ngongi 1998). It is therefore imperative to recognise that the extra labour requirements for improved poultry production will compete with existing activities in the smallholder-farming sector. Extra labour is only likely to become available for poultry production if the increased labour inputs are sufficiently rewarded and if the additional benefits accrued from the improved enterprise are enjoyed primarily by those who provide the extra labour (Rushton and Ngongi 1998). These benefits may be in the form of meat, eggs or cash.

Another factor to be considered is the access of poultry managers to capital. Capital is needed to get poultry production off the ground. Building and maintenance of good quality housing often requires a significant cash outlay even if local materials are used. Cash is also required for the purchase of feed, birds and disease control products such as vaccines (Chitate and Guta 2002). However, most of the poultry 'managers' being women do not have control over household cash resources, which are usually in the hands of men, nor do they have ready access to credit (Rushton and Ngongi 1998). It is generally difficult for farmers to access credit from formal lending institutions such as banks because of the farmers' lack of collateral and the unpredictable pattern of production in the smallholder-farming sector, which is at the mercy of natural elements making it difficult to guarantee the repayment of loans. Where credit is available for the farmers the interest rates tend to be very prohibitive. Farmers have had credit support in the form of savings clubs and young farmers' clubs but most of these clubs have been unsuccessful because of a lack of support and commitment

(Kusina and Mhlanga 2000). Non-Governmental Organisations have also come in to help with the provision of credit for smallholder farmers but very few of them are targeting smallholder poultry production.

Marketing of poultry and poultry products is a major issue in the smallholder-farming sector. A feasibility study carried out by the Household Agricultural Support Programme (HASP), showed that organised marketing was virtually none existent in the smallholder-farming sector (Kusina and Kusina, 1999). This is a major constraint to those anticipating making poultry production a viable and sustainable income-generating venture because the lack of organised marketing militates against enhanced revenue generation. This is particularly critical for broilers and eggs (Kusina and Mhlanga 2000). As a result, farmers continue to feed broilers past their culling date until a market becomes available because they do not have access to refrigeration facilities. The farmers incur substantial losses as a result. Potential markets such as growth points, local business centres and hospitals are not within easy reach of the farmers and the situation is compounded by a lack of reliable transport within the smallholder farming areas. As a result, the birds are marketed mainly to neighbouring farmers, fellow villagers and local civil servants. In the areas surveyed by Kusina and Mhlanga (2000), 60% of the farmers reported selling the broilers to other villagers, 3% to local teachers and 36% to both villagers and teachers. Because relatively few individuals are involved in hybrid poultry production in the peri-urban and communal areas, demand for broilers outstrips supply for long periods in a year (Hanyani-Mlambo 1999). The broilers from the smallholder-farming sector are sold as live birds and not after dressing as in the commercial sector (Chitate and Guta 2002). Pricing of the live birds is based on prevailing market conditions of supply and demand and the size of the bird, without much consideration to the actual weight as in the commercial sector (Hanyani-Mlambo 1999). Farmers rarely maximise their return from the sale of the birds because rural prices also tend to be affected by “affection forces” where exchange values are influenced by social ties within the community (Hanyani-Mlambo 1999). What this means is that, the price a farmer will charge a certain individual will depend on how close that individual is to her family. The farmer will charge less to her kinsmen and those close to her so as to maintain the existing close ties.

Health and diseases control is another factor affecting smallholder poultry production. A number of diseases are prevalent in the smallholder sector with Newcastle Disease being of notable influence on poultry production (Hanyani-Mlambo 1999). Most vaccines needed for maintaining the health of poultry are found to be too expensive to purchase by the smallholder farmers, who do not have much disposable income (Spradbrow 1999 and Oakley 1999). Added to this most vaccines especially for Newcastle Disease are heat sensitive and it is quite difficult to maintain a cold chain in most of the rural areas (Spradbrow 1999). This makes it difficult to find ways of storing the vaccines as well as transporting them to remote regions of Zimbabwe. Vaccines especially for Newcastle Disease are usually produced in large dose units, vials of 250, 500 and 1000 doses, which are more suitable for large commercial flocks rather than the small flocks kept by smallholder farmers (Spradbrow 1999). In order to make use of these vaccines it maybe necessary for the farmers to group themselves so as to make use of the vaccines. In many cases this is not easy as people might not be willing to cooperate or work due to traditional differences or cultural rivalries.

Customary practices can also complicate poultry health and vaccination campaigns. The transfer and movement of chickens between villages and regions is a common practise enabling owners to use birds for celebrations, gifts and ready sources of cash. These movements influence the epidemiology of the diseases and complicate the monitoring and control of vaccination covers (Oakley 1999). Mass vaccination campaigns are also hampered by the absence of producers at key times, as they will be attending to activities they deem more important and reporting of outbreaks following previous campaigns are not usually forthcoming (Oakley 1999).

The farmers interviewed in Mashonaland Central Province (Guruve) and Mashonaland East Province (Mutoko) clearly understood that, for a given breed of poultry, the major determinant of growth rate is accessibility to adequate, well-balanced feed supplies. However, normal practice involved the supplementation of indigenous poultry diets with poorly graded or spoiled grain, mainly maize. A few farmers used sunflower seeds and groundnuts. The use of oilseeds, or their extracts, was restricted to a few households; most farmers in the study areas did not own, or had access to, a sunflower ram press. Some farmers had begun experimenting with small quantities of bought-in concentrates, although the cash-flow problems regularly experienced by many communal farmers militated against the use of purchased feedstuffs. Consequently, the use of home-grown material as supplements in both indigenous and hybrid poultry production systems appeared to be an attractive, sustainable option, and many of the farmers interviewed appeared willing to grow additional grains and oilseeds. Some farmers appeared willing, if necessary, to rent additional land for this purpose. Farmers also recognised the need for better flock health management and better housing facilities. The study clearly showed that there was a resounding willingness in village women (the predominant poultry farmers) to introduce management systems that would increase the levels of production, consumption and income. They anticipated that with abundant feed resources, and an expected increase in flock size, the indigenous poultry produced would be equally used for home consumption and marketing. Poultry production was seen as generating more regular and reliable cash inflows.

The management if indigenous goats had continued to follow traditional systems of common pasture grazing and browsing, with very little dietary control. Goats also had access to crop residues during the dry season. Only a very small number of the farmers interviewed had fed their goats sunflower cake, partly because of the low availability of the cake, and partly because of a lack of knowledge of the potential advantages associated with supplementary feeding.

The marketing of indigenous poultry ($56.75 per kg, live-weight) had a much higher return than goat meat marketing ($11.60 per kg, live-weight). However, given the large cash injection associated with an occasional goat sale, those farmers interviewed perceived that the marketing of goats generated more income. The marketing of both poultry and goat meat reached a peak during the cotton marketing season (April to August) in Guruve, whereas the demand for goats was greatest during August to October in Mutuko. The consumption and marketing of goat milk was at an insignificant level.

It was considered that small-scale poultry production has the potential to enhance household incomes and food security as well as improve the nutritional status of the rural families. Small-scale poultry production can also be used as a tool for empowering the rural people especially women. However a number of institutional and socio-economic factors which still hinder the growth and development of small-scale poultry production in Zimbabwe were identified in the study. The factors include the farmers still perceiving poultry production as part of their livelihoods rather than as an enterprise, lack of prioritisation of small-scale poultry production research by government and researchers, lack of information/extension services in the communal areas and inaccessibility of markets.

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Output 2: Low cost fibre reduction methodology for application to sunflower and sesame oilcakes

Production of sunflower oilcake

The sunflower oil and cake produced by the Bienlenberg-type ram press possessed the following characteristics:

Characteristic	Quantity	
	Weight (g)	g/kg seed
Weight of sunflower seed	11,775.1	-
Moisture content of seed	877.2	74.3
Weight of sunflower seed cake	8,783.4	744.4
Moisture content of cake	900.3	[a]102.3
Weight of oil, including foots	2,618.1	221.9
Weight of strained material	304.2	25.8
Weight of strained oil	2,313.9	196.1
Weight of oil, cake & foots	11,401.5	966.2
Experimental loss	69.4	5.9

[a]g/kg seed cake

The sieving characteristics of (a) 150 g laboratory samples of sunflower seed cake and (b) a 4.0 kg sample of cake sieved using a 1.4mm, locally produced sieve are summarised below:

Sieve size (mm)	%age cake retained	%age cake passed	%age fibre	
			Retained	Passed
150g samples; laboratory sieves				
1.0	52.13	47.67	23.9	14.7
1.4	41.13	58.47	23.2	17.3
2.0	21.53	78.27	22.8	19.2
4.0 kg sample; locally constructed 1.4mm sieve				
1.4	43.31	56.27	22.0	16.7

Given the acceptable level of fibre (17.3%), and the comparatively high recovery of the material passing through the sieve (58.47%), all feeding trials were conducted using ram-pressed sunflower cake that had passed through a locally produced 1.4 mm sieve.

The nutritional characteristics of the cake, and of the other key ingredients, are given under Outputs 3, 4 and 5 (on-station poultry feeding studies; on-station goat feeding study; and on-farm poultry feeding study.

Output 3:

Performance characteristics of broiler feeds based on sunflower and sesame oilcakes with reduced fibre level, for use in peri-urban and rural poultry systems

A comparison of the on-station performance of village (indigenous) chickens, under improved feed management, with the performance of hybrid chickens
Chemical composition (AOAC, 1990) of the starter and finisher diets is given in Table 1. Table 2 shows the mean daily nutrient intake per bird for the different phases of growth.

Calcium to phosphorus ratio was 1.1. Both starter and finisher diets contained slightly more protein than recommended. Twenty per cent crude protein (CP) is recommended for starter phase (0-28 days) while 18% CP is recommended for the finisher phase (29-56 days).

The hybrid chickens consumed significantly more ($P<0.01$) nutrients than the village chickens at all stages of growth. The rate of nutrient consumption increased with age. Nutrient intake is related to the amount of feed consumed. At 0-28 days the hybrid birds consumed 24 % more feed than the village chickens, while at 35 and 56 days they consumed 31.9 and 39 % more feed respectively (Fig .2).

The village chickens consumed ($P<0.01$) less water than the hybrid chickens (Fig. 3) with hybrid consuming 46% more water at one week of age, increasing to 62% at 4 weeks and 73% at 8 weeks of age. Importantly, the village chickens also consumed less water per unit of feed than the hybrid birds (Fig. 3)

Live weight and feed conversion ratio (FCR)
Weight gains of village chickens at all phases of growth were significantly lower ($P<0.01$) than the hybrid chickens (Fig. 1). The hybrid chickens were 48% heavier than the village chickens at one week of age, 69% heavier at 28 days of age, 70% at 35 days and 78% heavier at 56 days of age.

Table 3 shows the feed conversion ratio of the village and hybrid chickens given commercial starter and finisher diets. The hybrid chickens were significantly more efficient ($P<0.01$) in feed conversion ratio at all phases of growth with a mean FCR of 2.5 ± 0.49 SD compared with FCR of 4.7 ± 1.4 SD in village chickens. Both village and hybrid chickens utilised feed more efficiently during the first 21 days of age than during the finisher phases. At 7-21 days of age, the hybrid chickens utilised feed at 40%-53% more efficiently compared to the village chickens, which were 57%-66% less efficient at 28-56 days of age.

Body composition
The mean weight of carcass components is presented in Table 4, while Figure 4 shows anatomical structures as percentage of carcass weight. Mean dressing out percentage in village and hybrid chickens, on empty body weight (EBW) basis, was 64% and 75% respectively, with carcass yields of 446 and 1539 g at 8 weeks of age. The heart, liver, lungs and wings relative to body weight in village and hybrid chickens grew at a similar rate, whereas the digestive tract, feet head and neck of village chickens grew at a higher rate ($P<0.05$) than in the hybrid chickens. However, the empty body weight of hybrid chickens

was significantly higher (P<0.05) than in the village chickens. Figure 5 shows bone to lean ratio in village and hybrid chickens. The bone: lean ratio is higher (P<0.05) in hybrid (1:4.3) than in the village chickens (1:2.3). Body weight in relation to the length of intestines ratio was higher in the village chickens (1:2) compared to the hybrid chickens (1:1) (Table 4). The nutrient composition of lean and bone in village and hybrid chickens is shown in Table 5. The crude protein content of meat was higher (P<0.05) in village chickens (73%) than in the hybrid birds (68%). However, village chickens were leaner (34%EE) than the hybrid (47%EE) at the same stage of growth. There were no differences in the protein and fat content in the bones of village and hybrid chickens.

Mortality and survival rate

Table 3 shows the mortality rate of village and hybrid chickens. Mortality was significantly higher (28%) in village chickens than in hybrid (8%). All the mortality, with the exception of 1% in hybrid chickens, occurred during the first three weeks of age.

Economics of village and hybrid chickens

Table 6 shows the economics of raising village and hybrid chickens under improved feed management. Feed accounted for 75% of the total variable cost (TVC). Village chickens consumed 55% of the feed consumed by hybrids and were 31% lighter than hybrids at 8 weeks of age. However, feed cost per kilogram of live weight was high in village compared to hybrid chickens. Higher gross margin, net profit and return per dollar invested were obtained from hybrid chickens, compared to village chickens. The differences in return per dollar invested between the village ($1.5) and hybrid ($1.8) chickens were small, although, statistical significance was reached.

Discussion

Maize *(Zea mays)*, constituting 60 – 64 % of the feed formulation, represents the most common energy feedstuff used in poultry diets. The metabolisable energy value (14.2 MJ/kg ME) is considered as a standard with which other energy sources are compared.

Minerals, calcium and phosphorus are important for skeletal growth. The National Research Council (NRC) (1984) recommends 10 g/kg Ca and 4.5 g/kg available phosphorus (AP) for maximum growth and bone formation of young chickens. However, substantial growth was obtained with 1:1 ratio of Ca and AP (Scot, Nesheim and Young, 1982). The efficiency of chickens to produce meat is measured by their rate of weight gain and carcass yield. Undeveloped tropical village chickens are reputed to have low production levels reflected in both low growth rates and carcass yields. In most of these birds it has not been fully established whether this low productivity is due to their genetic make up or to poor management.

In the present study village chickens:

- Had low growth rates reaching slaughter weights of 600 g at 8 weeks and 1500 g at 15 weeks, compared to 1950 g and 4500 g for hybrid chickens respectively

- Had a poorer feed conversion ratio than hybrid chickens. The cost of feed per kilogram of live-weight gain was 44% more in village chickens

- Produced low carcass yield in the form of dressing percentage and weight of offal. The hybrid birds produced high meat yields in the form of dressing percentage and empty body weight

- Produced carcasses of good quality, as reflected by high protein (73.2%) and low flat (34.1%). The carcasses of hybrid chickens had a high fat content (47%)

- Had a high mortality rate (28%) compared to hybrid birds (8%)

- Were less profitable than hybrid chickens, but still afforded a positive return per dollar invested ($1.5). Hybrid birds showed a $1.8 return per dollar invested.

The low growth rate of village birds indicates that they had a low response to improved feeding management systems. However, live weights of indigenous chickens in Malaysia under intensive systems of management showed lower live weights compared to those reported in the current study (Jalaludin *et.al,* 1985). These weighed 380 g at 8 weeks and 1170 g at 15 weeks. This could be attributed to the level of protein in the feed (Yeong, 1992). Village chickens raised intensively showed a better growth rate at 16 weeks of age when fed at a higher crude protein level: 1184 g live weight at 18% crude protein, 1254 g at 20% and 1409 at 23 % crude protein levels (Yeong, 1992). The crude protein level in the current study was 21%. The increase in body weight of hybrid appeared to be associated with an increase in water and feed intake (Marks, 1979; Siegel and Wisman, 1966). Accompanying their low body weight performance, village chickens had low carcass yield in the form of low dressing percentage and weight of offal. The low rate of growth of most internal organs indicates that their proportion in the slaughter weight will decrease, whereas the high rate of mesenteric fat increases with increased body weight.

Although the village chickens in the current study afforded a low carcass yield, Teketel (1986) found higher dressing percentage in indigenous chickens raised under station conditions compared with White Leghorns. The mean carcass weight of indigenous birds was 558g, a figure significantly lower than the 875g for White Leghorns at 12 weeks old. Indigenous chickens in this study were heavier than those reported above, weighing 600g at 8 weeks old.

In the current study, the cost of feed per kilogram of live-weight gain was 44% more in village chickens than in the hybrids. This difference is consistent with the low feed conversion ratio observed in village chickens. The hybrid birds produced high lean and low bone content. The bone content of the carcass is an important factor in determining meat quality. It has been shown that the proportion of bone in good carcasses does not exceed 14% (Hill, 1988). Hybrid carcasses in this study showed 13.8% bone, which is within the above range, while that of village chickens was 19%. The proportion of bone depends on the degree of finish of the carcass, the higher the fat percentage the lower bone content. However, village chickens produced carcasses with a low fat content. (The dietary concerns related to high fat in western diets may not be an issue in rural Zimbabwe, where animal fat is an important source of energy.) It has been observed that as chickens age the relative amount of energy required for growth declines (Marks 1979), the excess energy consumed may result in increased daily fat accretion (Robbins and Ballew, 1984). There is evidence to suggest that modern rapid growing hybrid broiler lack appetite regulatory mechanisms (Lacy, Van Krey and Denbow, 1983), suggesting their inability to adjust energy consumption for changes in the relative requirements for growth. The eviscerated carcass yield of village chickens (63%) in the current study was within the range 50% - 71% reported for indigenous chickens in Nigeria and Senegal (Joseph *et.al.* 1992).

All the mortality in village chickens occurred during the first 3 weeks of age. Laboratory investigations from post mortem of the dead chickens confirmed an outbreak of Bronchitis

Infectious Respiratory Disease (BIRD). Village chickens were more susceptible to the disease. It was speculated that the hybrid chickens could have acquired some immunity through the egg from their parents, since the parent stocks were selected and bred for growth and against some of the common diseases. Severe rearing losses, with high mortality in young indigenous chickens have been reported under traditional management systems to reach up to 50% up to 8 weeks in Burkina Faso (Wilson, 1986) and 68% up to 6 weeks in Nigeria (Ologhobo, 1992). Brannange and Pearson (1990) observed high incidences of mortality among indigenous birds when kept under confinement. This was attributed to the fact that indigenous birds are not accustomed to confinement and that diseases which are important under confined conditions, may have much more serious effect on local than exotic birds.

Gross margin analysis was employed to evaluate the economics of feeding commercial diets to village in comparison with the hybrid chickens. It was more profitable to feed the commercial diets to hybrid chickens than to village chickens. Both gross margin and net profit from village chickens were positive, demonstrating that relative profit could still be realized from the improved feeding management of village chickens.

Conclusions

This study has shown that under improved feed management, the performance of village chickens is low in terms of growth, late sexual maturity and high rearing mortality. This can be attributed, in part, to the lack of genetic improvement through selection or crossbreeding. However, village chickens have valuable traits such as meat of good quality with high protein (72.3%) and low fat (34.1%) compared with hybrids, which have low protein (69.7%) and high fat (47%). Village chickens were less profitable providing a net profit of Z$58, as opposed to Z$184 afforded by the hybrid birds. However, they still afforded a positive return per dollar invested of Z$1.5, compared to a return of Z$1.8, afforded by the hybrid birds. There is considerable scope to investigate the potential of village chickens under traditional low input/low output farming systems. The low feed conversion ratio in village chickens and the slow growth rates to maturity suggests potential to improve nutrition through use of locally available least cost feed resources.

Table 1. Ingredient % and chemical composition (g/kg DM) of the diets fed to village and hybrid chickens in the experiment

Concentrate diets		
Ingredient (%)	**Starter diet**	**Finisher diet**
Maize	60	64
Broiler concentrate	40	36
Chemical composition (g/kg DM)		
Crude Protein (CP)	224.0	210.0
Crude Fibre (CF)	30.0	37.4
Ether Extract (EE)	28.0	28.4

Ca	9.4	11.2
Available P	8.8	8.9
NaCl	2.2	2.5
ME (MJ/kg)	12.3	12.5
Methionine (%)	0.69	0.68
Lysine (%)	1.16	1.14

Table 2. Mean daily nutrient intake (g/bird/d) of village and hybrid chickens for different phases of growth, when fed commercial poultry diets *ad libitun*

Nutrient and Phase of growth	Village chickens	Hybrid chickens	s.e.m.	P value
CP 21 days	8.2	12.7	0.28	0.01
28 days	9.7	12.8	0.48	0.01
35 days	14	20.6	0.77	0.01
56 days	17.4	33.8	1.52	0.01
ME (MJ)21 days	0.45	0.71	0.16	0.01
28 days	0.45	0.71	0.22	0.01
35 days	0.87	1.3	0.48	0.01
56 days	1.08	2.1	0.71	0.01
*CF*21 days	1.1	1.7	0.38	0.01
28 days	1.5	2.4	0.74	0.01
35 days	2.7	3.9	0.84	0.01
56 days	3.3	6.4	0.22	0.01
*Ca*21 days	0.05	0.07	0.02	0.01
28 days	0.06	0.08	0.02	0.01
35 days	0.09	0.12	0.05	0.01
56 days	0.11	0.21	0.06	0.01
*Available P*21 days	0.05	0.08	0.02	0.01

28 days	0.06	0.09	0.03	0.01
35 days	0.09	0.14	0.07	0.01
56 days	0.11	0.22	0.09	0.01

Table 3. Mean feed conversion ratio, FCR (g feed per kg live weight) and mortality rate (%) of village and hybrid chickens

FCR					Mortality rate (%)	
Age (weeks)	**Village**	**Hybrid**	**s.e.m**	**P > F**	**Village**	**Hybrid**
1-3	3.0[a]	1.6[b]	0.09	0.001	28	7
4-8	5.5[a]	2.6[b]	0.57	0.001	Nil	Nil
9-12	4.9[a]	2.7[b]	0.33	0.001	Nil	Nil
13-16	5.4[a]	3.2[b]	0.26	0.001	Nil	1
Mean	4.7[a]	2.5[b]	0.18	0.001	28	8

[a b] Means in the same row with different superscripts differ significantly (P < 0.05)

Table 4. Mean weight of carcass components of village and hybrid chickens fed commercial diets *ad libitum*

	Village chickens	Hybrid chickens	s.e.m
Slaughter age (days)	63	63	
Plucked dead weight (g)	700[a]	2061.5[b]	1.02
Empty body weight (g)	231[a]	914.2[b]	1.54
Dressing Out (%)	63[a]	74.7[b]	0.9
Bone (g)	133[a]	284[b]	2.5
Lean (g)	310[a]	1222[b]	3.6
Head and neck (g)	71.5[a]	152.6[b]	0.65
Heart (g)	6.5[a]	11.6[b]	0.19
Lungs (g)	7.1[a]	17.4[b]	0.21
Liver, stomach, crop (g)	23.8[a]	64.7[b]	0.8
Digestive tract (g)	51[a]	110[b]	0.53
Wings (g)	66[a]	176[b]	0.97
Thighs and legs (g)	149[a]	449[b]	1.3
Feet (g)	37.7[a]	75.3[b]	0.24
Length of intestines (cm)	1264[a]	1738[b]	3.2
Length of caeca (cm)	109.6[a]	193[b]	1.2

[ab] Means on the same line with different superscripts differ significantly ($P<0.05$)

Table 5. Nutrient composition (percent) of lean and bone of carcasses in village and hybrid chickens given commercial diet

	DM	*CP*	*Fat (EE)*	*Ash*
Lean				
Village chickens	97.9[a]	73.2[a]	34.1[a]	9.9[a]
Hybrid chickens	97.8[a]	69.7[b]	47.0[b]	6.7[a]
s.e.m	1.23	2.84	3.91	2.13
Bone				
Village chickens	98.5[a]	25.4[a]	27.2 [a]	2.6 [a]
Hybrid chickens	98.2[a]	25.10 [a]	27.2 [a]	.5[b]
s.e.m	0.31	0.22	**0.09**	**1.24**

[a b] Means in the same column with different superscripts differ significantly (P < 0.05)

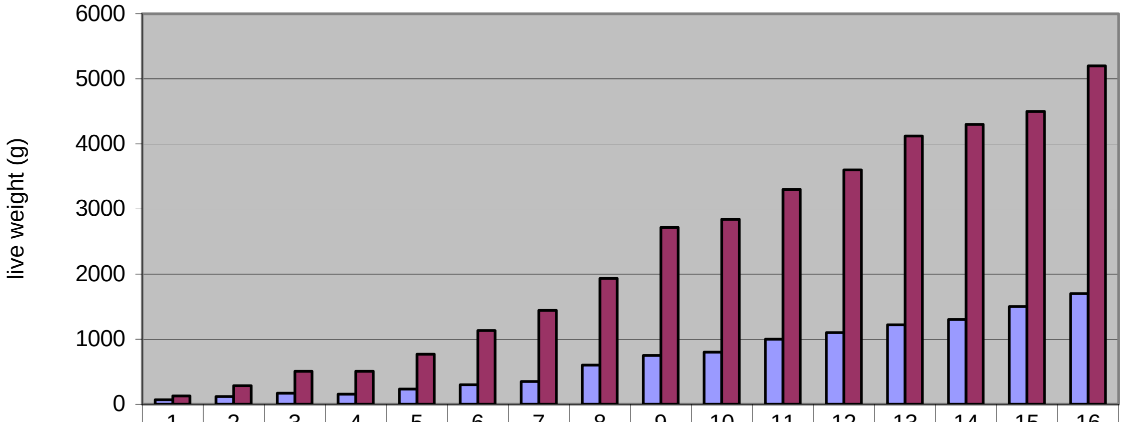
Table 6. The economics of feeding village and hybrid chickens on commercial diets: Mean values

	Village	Hybrid	s.e.m	P > F
Age (weeks)	8	8		
Feed consumption (kg)	2.72[a]	4.94[b]	2.2	0.001
Live weight (g)	600 [a]	1934 [b]	39.3	0.001
Carcass weight (g)	550 [a]	1280 [b]	30.8	0.001
[c]Gross Income (Z$)*	220 [a]	512 [b]	3.4	0.001
[d]Total Variable Costs, TVC (Z$)	147 [a]	286 [b]	0.53	0.001
Price of concentrate (Z$)*Price of maize (Z$)*[e]Gross Margin, GM (Z$)*	80 [a]31 [a]73 [a]	155 [b]60 [b]211 [b]	0.320.270.29	0.0010.0010.001
Feed cost/kg live weight (Z$)*	229 [a]	129 [b]	0.48	0.001
Net profit (Z$)*	58 [a]	184 [b]	0.51	0.001
Return per $ invested	1.5 [a]	1.8 [a]	0.13	0.001

[ab] Means in the same row with different superscripts differ significantly $P < 0.01$
** Rounded to the nearest dollar

[c]Gross Income = X*Y
[d]TVC Total variable costs = the cost of feed, water, day old hybrid chicks, hatching village chicks, labour. Feed = 75% of TVC
[e]Gross Margin = (X*Y) – (TVC)
Net Profit = (X*Y) – (TVC) – TVC*0.1)
Feed cost/kg Live weight = (C)/Live weight
Where: X = Carcass weight (kg)
Y = Price ($/kg) of dressed carcass weight
C = Cost of feed = (Feed consumed (kg) * Price of feed ($/kg)
Price of feed = ($101/kg for concentrate and $17/kg for maize)
Overhead costs (Often 10 % of TVC) = General operating costs of running project

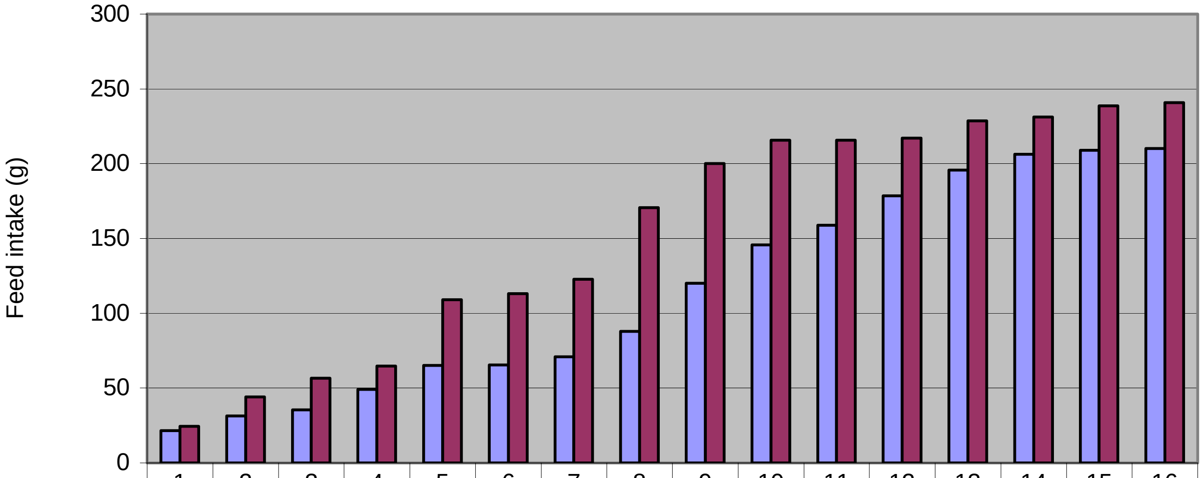
Fig. 1 Mean live weight (g/bird/week) of village and hybrid chickens given a commercial diet



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Village	66	117	169	154	230	299	348	600	750	800	1000	1100	1220	1300	1500	1700
Hybrid	126	286	507	503	768	1129	1440	1934	2716	2840	3300	3600	4120	4300	4500	5200

Age in weeks

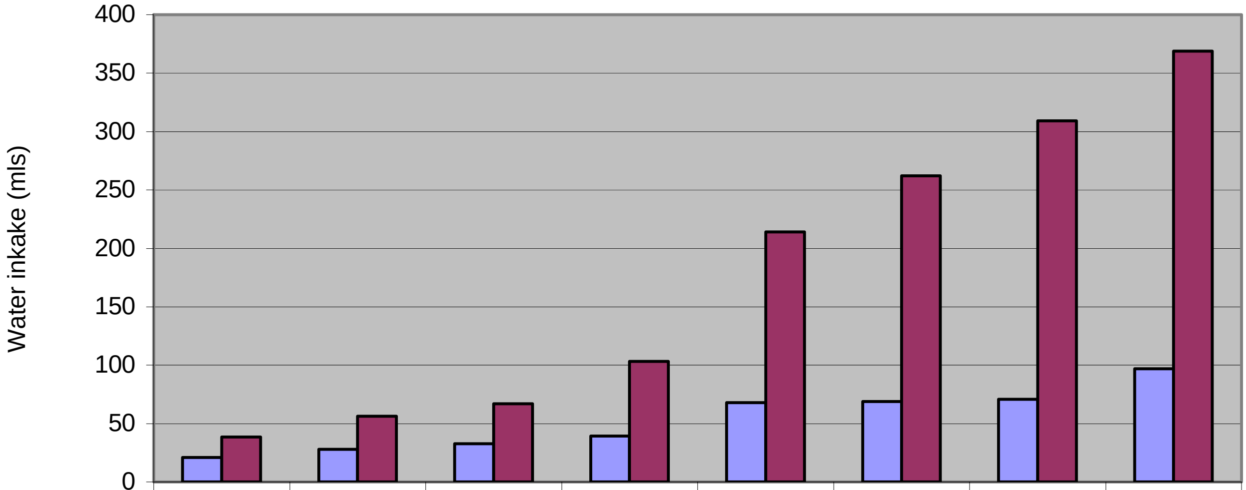
Fig. 2 Mean feed intake (g/bird/d) of village and hybrid chickens given a commercial diet



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Village	21.5	31.5	35.5	49.2	65.2	65.5	70.9	87.9	120	145.7	158.8	178.5	195.7	206.4	208.9	210.2
Hybrid	24.5	44.2	56.5	64.8	109.1	113.2	122.8	170.7	200	215.6	215.7	217.1	228.5	231.2	238.7	240.8

Age in weeks

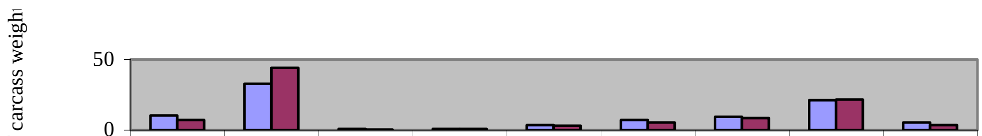
Fig. 3 Mean water intake (ml/bird/d) of village and hybrid chickens given a commercial diet



	1	2	3	4	5	6	7	8
Village	20.9	27.8	32.8	39.4	68	69	71	97
Hybrid	38.5	56.1	67	103.2	214	262	309	369

Age in weeks

Fig.4 Mean percentage of body weight of anatomical structures of village and hybrid chickens given a commercial diet



	H+N	EB	Hrt	Lu	Liv	Dtr	Win	T+L	Ft
Village	10.2	33	0.9	1	3.4	7.3	9.4	21.3	5.4
Hybrid	7.4	44.3	0.6	0.8	3.1	5.3	8.5	21.7	3.6

Body components

<u>Code</u>

Head and neck	H+N	Digestive tract	Dtr	Lungs	Lun
Empty body	EB	Wings	Win	Liver, stomach, crop	Liv
Heart	Hrt	Thighs and legs	T+L	Feet	Ft

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The on-station performance of commercial hybrid broilers when fed a variety of diets containing sunflower oilcake

Five diets were used during the on-station trials. Their composition in terms of maize, commercial concentrate and sunflower seed cake is shown in Table 1 with the approximate nutrient composition of each of the diets.

For each treatment in the trial, feed consumption was measured daily, weight of the birds was measured weekly and mortality was recorded as it occurred. The total feed consumed in a week in each treatment was divided by the number of birds in the treatment to give mean feed consumed per bird and the weight of the birds in the treatment was divided by the number of birds in the treatment to give the mean weight of each bird. Table 2, shows the mean weight of bird in each treatment each week, the feed consumed per bird per week and mortality for each treatment. The birds in each treatment were sexed in order to determine the ratio of males to females. This was done because males tend to be bigger than females and consume more feed which may have some effect on the results of the trial. The composition of males and females in the trials is shown in Table 3. The costs per kilogramme of the feed inputs, the cost of each day old chick as well as the selling price of broilers per kilogram is shown in Table 4.

Using the total feed consumed in each treatment and the costs of the feed inputs, the total feed costs were determined. The total costs were therefore determined from the total costs of day-old chicks and the feed costs. Market value of the birds was determined from the average cost of broilers per kilogram in the local markets in Harare multiplied by the total weight of the birds produced in each treatment. The profit was determined from the difference between the total costs and the market value of the birds as a percentage of the total costs. Table 5 shows the total costs of inputs, market value of products and potential profit for each treatment in the trial. Whilst Table 6 shows the mean total costs of inputs, market value of products and potential profit for each feed in the trial. Table 7 shows mean weight of each bird for the five diets over the eight week trial based on the measurements taken weekly during the trial.

A comparison of the mean final weights of the chickens for each of the five feeds in the trial is shown in the graph in Figure 1. Whilst Figure 2 shows a comparison of the average total feed intake per bird for each feed in the trial.

Feed intake in each treatment was determined daily during the trial and Table 8 shows the mean feed intake per bird per day for each of the five feeds in the trial based on the daily measurements.

Growing poultry use part of the feed they consume for maintenance and another part for growth. From the economic point of view, the part available for growth must be as high as possible. The Feed Conversion Ratio is the relationship between the weight of feed consumed and the chicken's weight gain during a given growth period. Table 9 shows the total feed consumed, weight gained and the feed conversion ration for each of the five feeds during the trial period.

The cost of producing a kilogram of live weight for each feed in the trial is shown in Table 10.

Discussion
One hundred and fifty broilers were used during the 8-week trial period. Mortality was low (4% of total) and was not influenced by dietary treatment. This is because all six birds lost in the 8-week trial, were lost in week 6 during which there was an outbreak of Bronchitis Infectious Respiratory Disease (BIRD) amongst the layers kept at Henderson Research Station. Infection is likely to have been carried over from the layers by the workers who were responsible for cleaning the poultry houses and changing the water. Post mortems carried out on the dead chickens at Mazowe Veterinary College confirmed BIRD as the cause of death of the six birds. Mortality was kept low by vaccinating through the eye, all the birds in the trial.

Five diets where used during the trial. Diet 1 acted as the control and was made up of 70% maize mixed with 30% concentrate. In diet 2 there was direct replacement of 10% of the concentrate with ram press sunflower seedcake, diet 3 had a 20% replacement, diet 4 had a 30% replacement and diet 5 had a 50% replacement. Two nutrients determine the quality of poultry feed; these are the crude protein and crude fibre content. The crude protein affects the growth and development of the bird, whilst the crude fibre affects the feed intake. According to literature, the minimum crude protein content for a broiler finisher diet is 18% (CAB 1987 and Parr 1988). Only the control, diet 1 (19.07% crude protein) and experimental diet 2 (18.49% crude protein) met this standard, the other three diets had protein contents below 18%. However, diet 3 with protein content of 17.8% and diet 4 with protein content of 17.6% were very close to the 18% minimum requirement whilst diet 5 with a content of 15.9% was well below. The protein contents for diets 2 to 4 met the nutrient specifications for appropriate density poultry feeds as set out by Parr (1988). All the five diets had a crude fibre content below the maximum specification for poultry feeds, which is 9% according to Parr (1988). Feed 5 with the highest ram press sunflower seed cake content had the highest crude fibre content of 6.18%.

The total feed intakes for diets 1 to 4 were above 5kg for the 8-week trial period with only diet 5 being below 5kg. These intakes of feed were consistent with those given in CABI (1987) and Parr (1988) for broilers reared in a tropical environment. The total feed intakes for diets 2, 3 and 4 were higher than those of the control diet, diet 1. The highest total feed intake over the 8-week period was for feed 3 where over the trial period the birds in treatment 3 consumed an average of 5.35kg each. There were no significant differences ($P>0.05$), in the mean daily feed intakes per bird for the five treatments. Even though there were differences in the amount of feed consumed per bird per day for the five feeds, these differences were not statistically different. Thus replacing up to 50% of the commercial concentrate in a broiler finisher diet with ram press sunflower seed cake had no significant effect on the amount of feed consumed by the chickens in the trial. This was probably because even though there was direct replacement of concentrate with ram press sunflower seed cake, the crude fibre contents of the diets remained below the maximum nutrient specification for crude fibre. Gender can also have an effect on the intake of feed by poultry. Males tend to consume more feed than females. As can be seen in table 5, the number of males and females were not distributed equally throughout the treatments. The amount of feed consumed in treatments that had more males than females were generally higher than those in treatments with more females than males. For diets 1, 2, 3 and 4, when both treatments are considered, the numbers of males and females even out and therefore the effect of gender on feed intake is minimised. However, for diet 5, the number of males in both treatments is considerably less than the females and this could have contributed to the low feed intake in this treatment.

All the birds in the five treatments managed to surpass the target weight of 2kg at 8 weeks of age. The heaviest birds were in treatment 3, where the birds had an average weight of 2.5kg at 8 weeks whilst the lightest were in treatment 5 were the birds had an average weight of 2.1kg. In fact, the chickens in treatment 3 (given diet 3, 30% sunflower cake), managed to reach the target weight of 2kg after 7 weeks of the trial. However, statistical analysis showed that there were no statistically significant differences in the body weights ($P>0.05$) of the chickens in the five treatments. This shows that the replacement of commercial poultry concentrate by up to 50% in the finisher diet does not depress growth of the chickens; this is probably because the protein contents of the four diets with ram press sunflower seed cake were still relatively high. The best feed conversion ratio (FCR) was recorded for birds on diet 2, which had an FCR of 2.16. The rest of the birds in the trial had acceptable feed conversion ratios that were below 2.5. According to CABI (1987), feed conversion ratios obtained in tropical countries should be between 2 and 2.5. Replacement of commercial concentrate with ram press sunflower seed cake resulted in the reduction of the total feed costs by up to 31% (diet 5) without significantly affecting the growth performance of the chickens.

It must be noted that, the poultry feeds under consideration in this study are made up of 70% maize just like commercial feeds. Maize is the staple food of Zimbabwe and the use of the diets under consideration will result in a competition between maize as feed and maize as food. For farmers who rear broilers this is a competition between income generation and food security. Food security is the availability of safe and nutritious food involving either the farmers growing their own food or the farmers being able to purchase food for their families. Hanyani-Mlambo (2002) states that farming in Zimbabwe's small-scale sector is not an enterprise but a livelihood, thus production is geared towards subsistence with produce only being sold when there is excess. However, from the trials carried out, for every Z$1 that the farmer puts into poultry production, he is able to get at least Z$1.58. This means that farmers should be able to use a portion of the proceeds of their poultry production to purchase maize and food security need not be compromised. The approach taken to determine the profitability of broiler production when there is direct replacement of commercial concentrate with sunflower seedcake in this study is summarised in table 8. The total cost of raising the broilers from day 1 to 56 was taken to be the total feed costs plus the cost of day old chicks. The market value was obtained from the costs of live chickens within the Mazowe area. The profit was the difference between the total costs of raising the broilers and their market value. Thus table 8 gives the potential profit to be made from using the 5 diets. It must be noted that the value of maize and sunflower seedcake vary from region to region whilst that of day-old chickens and commercial concentrate is basically constant throughout Zimbabwe. Maize becomes more expensive as you move south and westwards in Zimbabwe from Harare because the conditions become less favourable for its production. The value used was in this trial was based on the average from the villages around Henderson which is in the north of Zimbabwe. On the other hand, sunflower seedcake can be obtained for free or for a very minimal charge in most regions of Zimbabwe because many farmers view it as waste to be discarded and believe anyone who takes it from them is actually doing them a favour (Kanjanda 2001). Few farmers currently make good us of the seedcake. The value of Z$5.00/kg was obtained from Zimbabwe Oil Producers Project (ZOPP) and it is based upon the average price charged by ram press operators. Based upon this, the price of sunflower seedcake is normally far much less that of day-old chicks, maize and commercial concentrate. The birds would probably fetch a higher price on the open market in the city and if they were dressed. However, small-scale farmers usually sell live animals in their own villages and that was what was considered. Due to the short life cycle of chickens, poultry production can be a quick way of building up capital and thus improve the financial status of the farmers. Because of this Permin *et al*. (2001) says small-scale poultry production can be a self-sustaining and income-generating system that can serve to build-up an entitlement for women. In most cases women are responsible for poultry and it can therefore act as a tool for their empowerment.

Small-scale farmers in Zimbabwe tend to be very conservative and prefer to keep to traditional means of farming that have served them well for generations. However, there is now a growing new breed of farmers in the communal areas of Zimbabwe. This category of farmers is made up of people who have relocated from the urban areas in recent years due to wholesale retrenchments in industry, downsizing of the civil service and private sector as well as people retiring from work without sufficient pensions to maintain them in the urban areas. These farmers are likely to be more willing to use their maize for feeding their poultry if they can see the benefits to be gained from these feeds. This new breed of rural settlers has on average a better level of education than the average small-scale farmer. They also tend to be more enterprising, enjoy greater extension-worker contact, have greater access to communication channels, have greater empathy, they are more cosmopolite and less dogmatic as well as having a more business-like approach to farming (Hanyani-Mlambo 1999). Because of this, they are more receptive to new technologies and innovations and are most likely to be willing to adapt the sunflower seed cake maize based diets, as their production costs will be lowered by their use.

The adoption of the diets may also be hindered by the extra labour required in their preparation. Labour is a problem in the rural areas of Zimbabwe and women who are usually responsible for poultry already have other duties to attend to. Men are more likely to be willing to help out women with their labour once they realise the benefits to be accrued from the use of the improved diets. For the diets to be adopted people have to be taught about them and this requires a good extension service. Most of the poultry farmers are women and a majority of the extension workers are male.

Zimbabwean women are traditionally very reserved when dealing with men or a stranger, which makes it difficult for them to gain the full benefits of researches such as this one. As a result of their being reserved, researchers and extension workers have tended to approach the farmers as being ignorant and them being knowledgeable. Out of respect the people tend to sit and listen but do not adapt the new technologies. Thus carrying out part of the research in the rural areas with the involvement of the women becomes very important so as to increase the chances of the technologies being adapted. Another important issue is that due to a lack of funds, the government extension services no longer moves around advising farmers on their problems but now require the farmers to go to the offices of the extension services if they want help. This means that only the more enterprising farmers are now benefiting from the extension services.

However, the tendency amongst farmers is that, if they see someone who has adapted a new technology and is benefiting fully from it then the less enterprising farmers are likely to follow as well.

Conclusions

From the work carried out at Henderson Research Station, it has been found that sunflower seed cake can be used to replace commercial feed concentrate up to 50% without significantly affecting the growth performance and feed intake of the chickens. In fact from the work carried out, chickens given a diet were 30% of the commercial concentrate was replaced by sunflower seed cake actually performed better than chickens that were given a diet with just commercial concentrate and maize. The replacement of commercial concentrate with sunflower seed cake also had the effect of reducing the overall costs of the poultry feed, which is a desirable outcome for small-scale farmers if it makes the feed more affordable for them. However, the level of reduction in the feed costs and the margin of profitability will probably vary from region to region. In this trial it was seen that the feed cost of producing 1 kilogram of live weight could be reduced from about Z$30/kg when using conventional feed to about Z$25/kg with 50% replacement of the concentrate. The trials also showed that poultry production using sunflower seed cake is profitable with the farmer being able to make at least Z$1.58 for every Z$1.00 that he puts into poultry production. The study also noted that there are a number of issues and socio-economic factors, which still hinder the growth of poultry production. The cost of poultry feed was found not to be the only issue affecting the production of poultry. The farmers have limited access to markets for their products, there are no credit facilities to enable them to invest in poultry production, and they lack access to the latest production information, extension and veterinary services. Some of their cultural and social practises still hinder them in their poultry production. It was also noted that in many cases, it is difficult for the small-scale communal farmers to be able to take on-board the results of on-station trials and there is a need for the farmers to actually be involved in the trials themselves.

Table 1: Composition of the five diets used in the trials

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Ingredients					
Maize (%)	67	67	67	67	67
Concentrate (%)	33	30	26.4	23.1	16.5
Sunflower seed cake (SSC) (%)	0	3	6.6	9.9	16.5
Ratio of SSC: Concentrate (%)	0	10	20	30	50
Analysis					
Crude Protein	19.07 %	18.49 %	17.8 %	17.6 %	15.9 %
Crude Fat	3.51 %	4.41 %	5.49 %	6.49 %	8.47 %
Crude Fibre	3.69 %	4.15 %	4.69 %	5.19 %	6.18 %
Calcium	0.90 %	0.83 %	0.73 %	0.64 %	0.49 %
Av. Phosphorous	0.54 %	0.51 %	0.47 %	0.43 %	0.36 %

Table 2: Table showing mean weight, feed consumed per bird per week and mortality for each treatment.

		Trt 2A	Trt 5B	Trt 4A	Trt 1B	Trt 5A	Trt 3B	Trt 1A	Trt 2B	Trt 3A	Trt 4B
Wk 1	Mean wt of bird (g)	126	124	128	128	130	130	124	127	127	130
	Mean feed Consumed (g)	140	147	140	133	140	133	140	147	140	154
	Mortality	0	0	0	0	0	0	0	0	0	0
Wk 2	Mean wt of bird (g)	293	293	257	294	308	300	277	298	304	278
	Mean feed Consumed (g)	301	308	322	301	308	294	301	315	308	294
	Mortality	0	0	0	0	0	0	0	0	0	0
Wk 3	Mean wt of bird (g)	540	510	490	540	540	530	540	530	530	510
	Mean feed Consumed (g)	441	427	427	427	441	441	413	441	441	427
	Mortality	0	0	0	0	0	0	0	0	0	0
Wk 4	Mean wt of bird (g)	860	730	810	700	840	820	830	850	830	820
	Mean feed Consumed (g)	469	476	469	441	476	497	469	490	476	476
	Mortality	0	0	0	0	0	0	0	0	0	0
Wk 5	Mean wt of bird (g)	1090	980	1250	1210	1230	1290	1070	1310	1270	1220
	Mean feed Consumed (g)	588	490	763	833	784	868	560	826	868	826
	Mortality	0	0	0	0	0	0	0	0	0	0
Wk 6	Mean wt of bird (g)	1300	1310	1510	1620	1370	1630	1420	1720	1660	1580
	Mean feed Consumed (g)	714	798	868	840	882	910	728	917	910	931
	Mortality	0	0	0	0	2	0	0	1	0	3
Wk 7	Mean wt of bird (g)	1810	1700	1950	2050	1720	2100	1890	2190	2090	2030
	Mean feed Consumed (g)	847	973	1015	1064	735	1036	1015	1085	1015	1078
	Mortality	0	0	0	0	0	0	0	0	0	0
Wk 8	Mean wt of bird (g)	2330	2130	2410	2510	2130	2530	2370	2660	2490	2430
	Mean feed Consumed (g)	1190	1169	1176	1232	1113	1176	1197	1281	1190	1169
	Mortality	0	0	0	0	0	0	0	0	0	0

Table 3: Composition of the different treatments at the end of the trials

Treatment	Males	Males as percentage of total	Females	Total
2A	5	33.3%	10	15
5B	5	33.3%	10	15
4A	7	46.7%	8	15
1B	8	53.3%	7	15
5A	3	23.1%	10	13
3B	12	80%	3	15
1A	8	53.3%	7	15
2B	7	50%	7	14
3A	3	20%	12	15
4B	5	41.7%	7	12

Table 4: Cost of inputs and outputs in the trial

Input/output	Cost
Broiler concentrate	Z$30.15/kg
Maize	Z$6.30/kg
Ram press sunflower seed cake	Z$2.25/kg
Day old chicks	Z$22.00 each
Broilers	Z$60.00/kg

Table 5: Total costs of inputs, market value of products and potential profit for each treatment in the trial.

Treatment	Total Cost Feed (Z$)	Purchase Cost of Birds (Z$)	Total Costs (Feeds + Birds) (Z$)	Market Value of Birds (Z$)	Profit (%)
[a]2A	968.38	330	1298.38	2097.00	61.5%
[a] 5B	770.52	330	1100.52	1917.00	74.2%
[a] 4A	955.97	330	1285.97	2169.00	68.7%
[a] 1B	1142.85	330	1472.85	2259.00	53.4%
[a] 5A	734.89	330	1064.89	1661.40	56%
[a] 3B	971.06	330	1301.06	2133.00	63.9%
[a] 1A	1045.94	330	1374.94	2394.00	74.1%
[a] 2B	1074.37	330	1404.37	2234.40	59.1%
[a] 3A	1033.55	330	1363.55	2241.00	64.4%
[a] 4B	865.55	330	1195.55	1749.60	46.3%

[a] Refers to diets described in Table 3.

Table 6: Mean total costs of inputs, market value of products and potential profit for each feed in the trial.

Feed	Mean total Cost Feed (Z$)	Purchase Cost of Birds (Z$)	Mean total Costs (Feeds + Birds) (Z$)	Mean market Value of Birds (Z$)	Mean profit (%)
1	1094.4	330	1424.40	2326.50	63.3%
2	1021.38	330	1351.38	2165.70	60.3%
3	1002.31	330	1332.31	2187.00	64.2%
4	910.76	330	1240.76	1959.30	57.9%
5	752.71	330	1082.71	1789.2	65.3%

Table 7: Mean weekly body weights in grams for the five diets in the treatments over the 8-week trial period

Feed	1	2	3	4	5	Standard error of means (s.e.m)	Standard error of differences of means (s.e.d)	Analysis of Variance (F pr.)
Weight wk1	124.7g	127.4g	129.4g	129.2g	126.4g	2.053	2.904	0.609
Weight wk2	277.1g	301.1g	307.6g	268.4g	296.8g	2.890	4.080	0.008
Weight wk3	533.0g	539.7g	534.7g	500.8g	521.9g	8.640	12.220	0.151
Weight wk4	763.0g	856.0g	826.0g	815.0g	784.0g	40.700	57.500	0.700
Weight wk5	1170.0g	1168.0g	1269.0g	1231.0g	1122.0g	114.500	162.000	0.859
Weight wk6	1539.0g	1490.0g	1638.0g	1542.0g	1351.0g	127.400	180.100	0.578
Weight wk7	1993.0g	1976.0g	2087.0g	1987.0g	1723.0g	102.700	145.200	0.284
Weight wk8	2453.0g	2482.0g	2505.0g	2418.0g	2137.0g	88.700	125.400	0.177

Fig 1: Graph showing comparison of final weights of chickens in the trial after 56 days

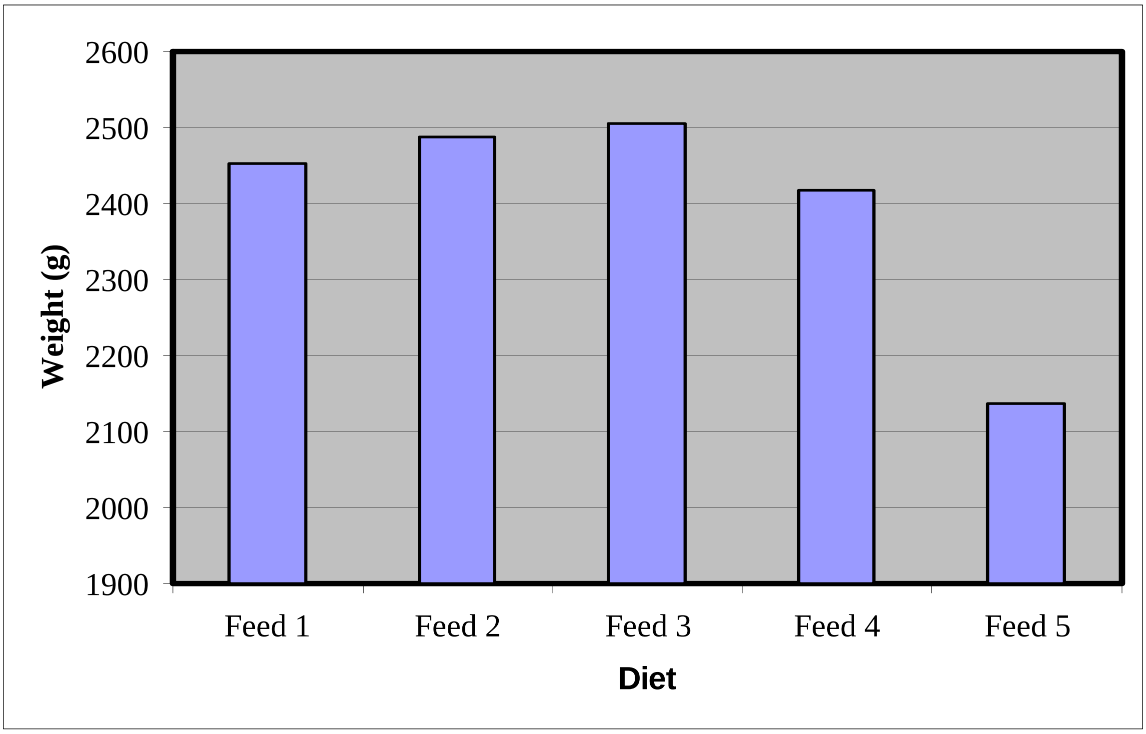

Fig 2: Graph showing average total feed intake per bird for each diet in the trial

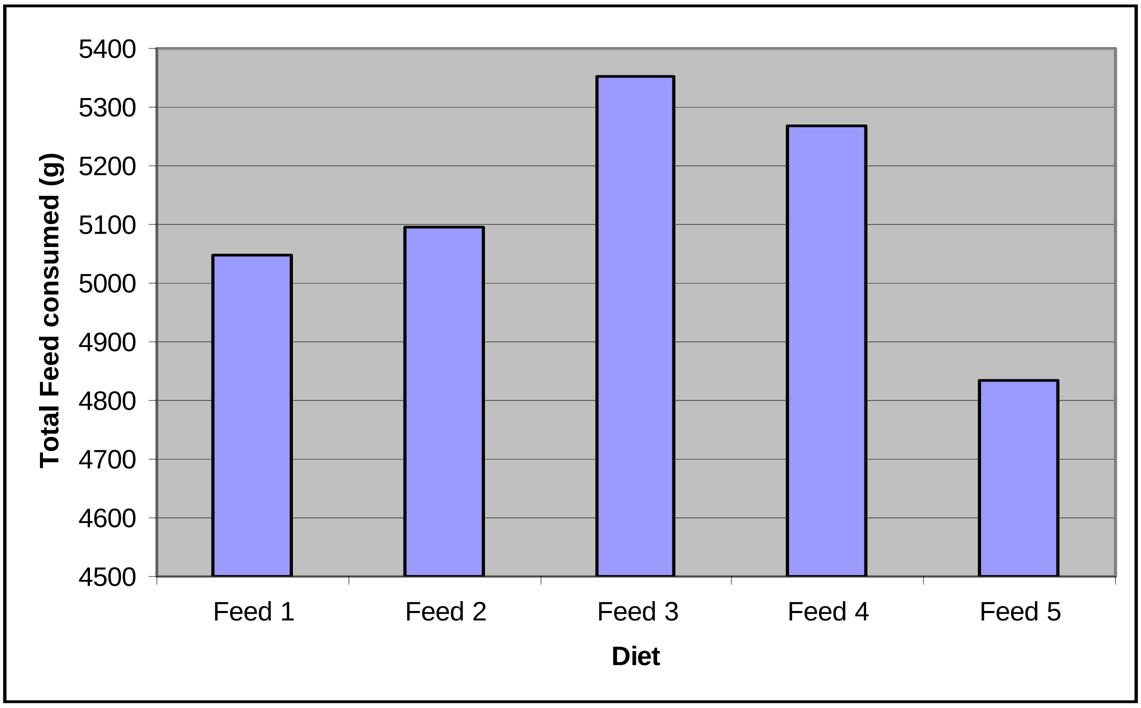

Table 8: Mean weekly feed intakes for the five diets in the treatments measured in grams per bird during the 8-week trial period.

Feed	1	2	3	4	5	Standard error of means (s.e.m)	Standard error of differences of means (s.e.d)	Analysis of Variance (F pr.)
Feed Intake wk1 (g/bird/d)	19.5g	20.5g	19.5g	21.0g	20.5g	0.671	0.949	0.500
Feed Intake wk2 (g/bird/d)	43.0g	44.0g	43.0g	44.0g	44.0g	1.140	1.612	0.908
Feed Intake wk3 (g/bird/d)	60.0g	63.0g	63.0g	61.0g	62.0g	0.707	1.000	0.131
Feed Intake wk4 (g/bird/d)	65.0g	68.5g	69.5g	67.5g	68.0g	1.440	2.037	0.386
Feed Intake wk5 (g/bird/d)	99.5g	101.0g	124.0g	113.5g	91.0g	16.210	22.920	0.662
Feed Intake wk6 (g/bird/d)	112.0g	116.5g	130.0g	128.5g	120.0g	7.780	11.010	0.506
Feed Intake wk7 (g/bird/d)	148.5g	138.0g	146.5g	149.5g	122.0	7.650	10.820	0.225
Feed Intake wk8 (g/bird/d)	173.5g	176.5	169.0g	167.5g	163.0g	3.130	4.430	0.170

Table 9: Table showing mean Feed Conversion Ratios for each of the five feeds in the trial.

Feed	Total Feed Consumed (g)	Weight Gained (g)	Feed Conversion Ratio (FCR.)
1	5047	2328	2.17
2	5096	2355	2.16
3	5352	2376	2.25
4	5268	2289	2.30
5	4834	2011	2.40

Table 10: Table showing the mean feed cost per kg of live weight for each of the feeds in the trial

Feed	Mean total Cost Feed (Z$)	Live Weight (kg)	Feed cost/kg live weight (Z$)
1	1094.4	36.6	29.90
2	1021.38	36.2	28.21
3	1002.31	37.6	26.66
4	910.76	32.6	27.94
5	752.71	29.8	25.23

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Output 4: Performance characteristics of small-ruminant feeds based on sunflower oilcake

On-station goat feeding study

Animal Health

Three animals died and one was removed from the experiment due to a fracture it sustained. These were one each from treatments one and three, while two were from treatment four.

Feed Intake

Intake data are presented on dry matter basis in Table 2. There were no significant (P>0.05) treatment differences on feed intake. There was however a tendency to depress basal diet intake with supplementation. The animals averaged 343.07 g d^{-1} basal diet intake. On metabolic weight basis the basal diet intake was 46.23 $g/kg^{0.75}/d$. There was a tendency to substitute for maize stover with supplementation. All indices for basal diet intake were less than 1. The animals on 30 and 45 $g/kg^{0.75}/d$ SFC selected against SFC and were not consuming all that was offered. Total feed intake was consequently not significantly (P>0.05) different as well across diets. Total feed intake averaged 413.92 g d^{-1}. At 45 $g/kg^{0.75}/d$ SFC supplementation, the animals ate very little of the cake compared to that at 30 $g/kg^{0.75}/d$.

Growth rate

Data on initial weight, final weight and weight change are shown in Table 3. There were no significant (P>0.05) treatment differences in these parameters. All animals in the four treatments lost weight. The average weight loss across treatments was –0.014 kg d^{-1}. With supplementation, body weight losses tended to be more severe.

The pattern of change in weight is shown in Figure 1. While the control dietary treatment maintained consistently higher weight throughout, the supplemented regimes maintained their weights at a lower level. The supplements in terms of mitigating severity of weight losses could be ranked as 45 $g/kg^{0.75}$ > 30 $g/kg^{0.75}$ > 15 $g/kg^{0.75}$.

Discussion

Dry season herbage from tropical and subtropical natural pasture is low in nitrogen and high in fibre (Minson, 1982) as was the case of the basal diet in this study. Both these factors contribute to the slow rate and low extent of digestion, resulting in low intake due to gut fill leading to poor animal production due to low nutrient supply. In this study maize stover was mixed with sunflower heads and groundnut tops to boost the nitrogen and energy of maize stover so that the animals receiving this treatment could survive.

Nitrogen and energy supplements increase the nutrient supply to the animal by altering digestion kinetics and intake (Faichney, 1996). However in this study there were no significant (P>0.05) differences in intake and growth performance amongst the different treatment groups.

It was anticipated that SFC would provide nitrogen and energy to enhance microbial proliferation in the rumen leading to greater dietary fermentation and also supply unfermentable digestible nitrogen to post-ruminal sites. The fat in SFC would have increased the energy density with the long chain fatty acids being metabolized more efficiently and the nitrogen providing a source of nitrogen for microbial growth and also some unfermentable digestible protein. Mupeta *et al.* (1997) using the mobile nylon bag technique, showed SFC to have the highest amino acid digestibility of individual amino acids, total amino acids and nitrogen compared to cottonseed meal, milkflow, groundnut tops and cowpea hay. However, in the current study, inclusion of SFC actually depressed total dietary intake and at 45 g/kg$^{0.75}$/d supplementation, the animals actually selected against SFC.

Only three to five per cent unprotected fat appears to be tolerated by rumen microorganisms (Devendra and Lewis, 1974; Palmquist and Jenkins, 1980; Chalupa, Rickabaugh, Kronfeld and Sklan, 1984). The SFC used in this study had 34.2 per cent ether extract content while the basal diet had 5.1 per cent ether extract.

When extracted oils are fed to ruminants, they rapidly undergo lipolysis in the rumen and since they will be mainly in the form of triacylglycerols, they yield glycerol and free fatty acids. Glycerol is quickly fermented mainly to propionic acid. Free fatty acids can then either be incorporated into microbial lipid, for calcium or magnesium soaps (Jenkins and Palmquist, 1982), biohydrogenated if they are unsaturated or modified by the formation of geometrical (*trans*) from positional (*cis*) isomers or simply become adsorbed onto the solid surface of the digesta (Harfoot, Noble and Moore, 1973).

These processes of fat digestion have a great bearing upon rumen fermentation. Reports have been made of changes in microbial populations (White, Grainger, Baker and Stroud, 1958), ammonia, methane (Czerkawski, Blaxter and Wainman, 1966) and volatile fatty acid production (Ikwuegbu and Sutton, 1982) and of reduced cellulose and fibre digestion (Kowalczyk, Orskov, Robinson and Stewart, 1977) if levels greater than five per cent are included in the diet. However, the severity of such effects are modified by many dietary factors.

Several hypotheses have been advanced as explanation for these observed effects of fats. Physical coating of fibre with fat preventing microbial attack and or inhibition of microbial activity from surface active effects of fatty acids on cell membranes (Jenkins and Palmquist, 1982) are the more likely explanations.

This is probably what was occurring in this study. The very high ether extract content in SFC and the inherent high level of ether extract in the basal diet, probably caused by whole seed not totally removed from the sunflower heads, could have adversely affected SFC utilisation, in terms of the protein and energy, leading to poor performance of kapeters on SFC supplemented regimes.

It is concluded that the efficiency of oil extraction using ram press machines and removal of seed from the sunflower heads needs to be improved if the cake is going to be used in ruminant animal production. This would also enhance profitability of oil production and greater use of protein in SFC. Also incorporation of SFC in complete diets with very little inherent fat content can be exploited to dilute the negative effects of fats beyond the maximum permissible limit. Further studies however need to be conducted to assess the implications of these diets on rumen fermentation.

Table 1 Chemical composition of feedstuffs (%)

Constituent	Ingredients				
	Maize stover (MS)	Sunflower cake (SFC)	Sunflower head (SFH)	Groundnut tops (GNT)	MS, GNT and SFH
Dry matter	95.2	96.6	94.4	93.8	94.0
Ash	5.7	5.1	14.8	8.8	11.2
Crude protein	3.5	20.5	9.3	11.2	5.7
Ether extract	3.2	34.2	7.9	2.6	5.1
Neutral detergent fibre	82.1	49.6	51.2	68.4	75.3

MS, GNT and SFH were mixed at 6:3:1 ratio, respectively.

Table 2 Mean basal diet (BD), sunflower cake (SFC) and total feed intake (TFI) of kapeters offered the same basal diet and supplemented with varying levels of sunflower cake. Relative values are expressed as a proportion of that of the unsupplemented diet.

Parameter	Dietary treatment				MSE	Sign.
	Control	15 g/kg$^{0.75}$/d	30 g/kg$^{0.75}$/d	45 g/kg$^{0.75}$/d		
BD intake d^{-1}	431.64	309.63	301.00	330.00	226698.40	NS
Index	1	0.71	0.69	0.76		
BD intake/kg$^{0.75}$/d	54.66	43.40	40.83	46.03	102.10	NS
Index	1	0.72	0.70	0.76		
SFC intake d^{-1}	-	75.66	102.84	104.98		
TFI d^{-1}	431.64	385.19	403.84	434.99	10320.60	NS
Index	1	0.89	0.94	1.01		
TFI/kg$^{0.75}$/d	54.66	55.54	55.69	61.00	59.59	NS
Index	1	1.02	1.02	1.12		

Basal diet had maize stover, groundnut tops and sunflower heads mixed in the ratio 6:3:1, respectively.

MSE = mean square error obtained from ANOVA table

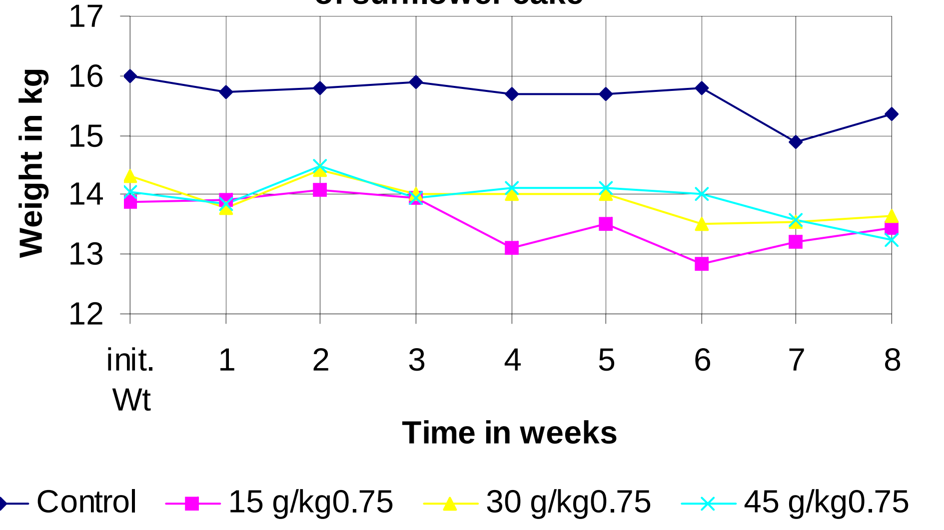
Sign = significance

Table 3 Effects of supplementation of a low quality basal diet (BD) with sunflower cake (SFC) on live body weight (kg) changes in kapeters.

Parameter	Dietary treatment				MSE	Sign.
	Control	15 g/kg$^{0.75}$/d	30 g/kg$^{0.75}$/d	45 g/kg$^{0.75}$/d		
Initial weight	16.00	13.88	14.32	14.05	9.080	NS
Final weight	14.17	13.98	13.85	13.66	1.078	NS
Body mass (BM) change	-0.385	-0.578	-0.705	-0.896	1.078	NS
BM change d^{-1}	-0.0069	-0.0103	-0.0126	-0.0160	0.00034	NS

Basal diet had maize stover, groundnut tops and sunflower heads mixed in 6:3:1 ratio, respectively.
Sign.= significance

Fi gure 1: Growth performance of kapeters offered the same basal diet supplemented with varying levels of sunflower cake



Control	16	15.74	15.8	15.88	15.7	15.7	15.8	14.88	15.34
15 g/kg0.75	13.88333333	13.91667	14.08333	13.93333	13.1	13.51667	12.85	13.2	13.43333
30 g/kg0.75	14.32	13.78	14.4	14.02	14	14.02	13.5	13.54	13.66
45 g/kg0.75	14.05	13.85	14.475	13.95	14.1	14.1	14.025	13.575	13.25
	init. Wt	1	2	3	4	5	6	7	8

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Output 5: Replication of feeding trials which demonstrated optimal results under controlled conditions, by village level small-scale poultry and goat producers

On-farm (village level) poultry studies

Feed

Table 1 shows the chemical composition of the homegrown feed ingredients, commercial starter and low-fibre SFR diets. Compared with the original sunflower residue, the low-fibre SFR fraction contained 28% less fibre and 14% more protein. There were no differences in the content of oil (EE), energy (MJ/kg), minerals (Ca and P) and amino acids (methionine and lysine). The SFR diet was high in fibre (7%) and oil (12%) than the recommended limits of up to 5% fibre and 3% fat. However, protein content of SFR diet (19.6%) was within recommended level (18%) for the finisher phase (29–56 days).

Table 2 revealed that hybrid chickens in general consumed 64% more feed at 8 weeks and 65% at 12 weeks than village chickens ($P < 0.001$). At 8 and 12 weeks hybrid chickens raised in pen consumed 25% more feed than those raised on the free-range, while village chickens in pen consumed 23% more feed at 8 weeks and 34% more at 12 weeks than those on free-range ($P < 0.05$; Fig. 2).

Water

Hybrid chickens consumed more water than village chickens ($P < 0.01$), being 70% and 76% at 8 and 12 weeks respectively (Table 2). The water: feed ratio was significantly high ($P < 0.05$) in hybrid chickens (2.1 – 2.2) compared with village chickens (1.6 – 1.7) at 8 weeks. However, at 12 weeks, there were no significant differences in water: feed ratio between village chickens (1.8 -–1.9) and hybrid chickens (2.0 – 2.2). Fig. 3 shows that the differences in daily water consumption (26%) between village chickens in pens and those on free-range at 12 weeks was higher than 5% in hybrids ($P < 0.05$). At 8 weeks the difference was 29% between village chickens and 20% between hybrid chickens.

Live weight

In Table 2, weight gain of village chickens in pen (724 g) and free–range (703 g) was low compared with the hybrid chickens (2425 g and 1955 g respectively ($P < 0.001$). While hybrid chickens in pens were significantly heavier (25%) than those on the free–range ($P < 0.05$), the differences between village chickens in pens and those on the free-range was small (3 -11%) at 8 and 12 weeks respectively ($P > 0.05$). At 8 weeks, feed efficiency in free-range village chicken (2.6) was similar to that of hybrid in pen (2.6), hybrid on free-range (2.7). This was significantly more efficient than in village chickens in pens (3.2). However, at 12 weeks FER in hybrid chicken decreased to 4.0 for hybrid in pen and 4.2 for hybrid on the free-range, while the FER in village chicken improved to 3.0 in village chicken in pen and 2.6 in village chicken on free-range.

Carcass quality

Carcass characteristics of hybrid and village chickens are given in Table 4. Both, plucked dead weight and dressing percent were high ($P < 0.05$) in hybrid chickens compared with village chickens at 8 weeks. But, at 12 weeks the differences in dressing percent was small and not significant. The meat to bone ratio was high ($P < 0.05$) in hybrid chickens (4.1-4.5) compared with village chickens (2.8-3.2). Meat yield at 8 weeks for instance, was less in village chickens (291-296 g versus 876-1096) due to differences in the shape of their growth curves. Village chickens significantly accumulated more protein concentration in their meat, while hybrid chickens consistently accumulated more fat.

Management effect

Table 4 shows the effects of the farmer (management) on the performance of chickens raised in pens and on the free-range, given low-fibre sunflower residue diet. There were significant differences ($P < 0.05$) in mortality between some of the farms. Farm 4 experienced the highest mortality (10%) followed by Farm 3 (7.5%) and Farm 9 (5%), while Farms 1, 5, 6 and 7 recorded zero mortality. Significant differences in live weight were observed during week 5, with farms 4 and 3 producing lighter chickens, while Farms 7, 6, 1 and 2 showed better performance in water and feed consumption.

Profitability

The profitability of feeding low-fibre SFR diet to hybrid and village chicken raised in pens and on the free-range is given in Table 5. Hybrid chickens showed high gross margin at 8 and 12 weeks ($P < 0.001$) compared with village chickens. But, at 12 weeks, the return per dollar was more favourable in village chickens (1.48–1.61) compared with hybrid chickens (1.2–1.3) ($P < 0.01$). At 8 weeks return per dollar was low in village chickens in pens and high for hybrid chickens in pens, while no differences were observed between village and hybrid chickens on the free-range (1.55 and 1.60 respectively). Within hybrid chickens gross margin and return per dollar was low on the free-range chickens than the chickens in pen. In contrast, village chickens on the free-range showed high gross margin and return per dollar ($P < 0.05$) than village chickens in pen. At 12 weeks compared with 8 weeks, gross margin in hybrid chickens declined, while an increase was observed in village chickens.

Discussion

In the present study, low-fibre SFR diet was given to hybrid and village chickens raised in pens and on the free-range, being managed by 10 women at their homesteads in Zimbabwe. The low-fibre was achieved by passing SFR through a 1.4 mm screen to recover the low-fibre, high protein fraction for inclusion in poultry diets. Reduction in fibre content was important, since fibre causes negative utilization of energy. The corresponding reduction of chlorogenic acid, a phenolic compound associated with sunflower hulls is important since it is known to interact with the amino group of lysine and thus decrease its availability (Sen and Bhattacharyya, 200).

Live weight and feed consumption

Indigenous chickens are genetically slow growing and tend to have low mature body weight at the same age as hybrid chickens. This was demonstrated in the current study where hybrid chickens were heavier (2425 g in pens and 1955 g on the free-range) than village chickens (724 g in pens and 703 g free-range village). However, these weights were higher when compared with 600 g in village chickens and 1950 g in hybrid when a standard commercial diet was given (Mupeta *et al*., 2002).

At 8 – 12 weeks, hybrid chickens in pen were 19% heavier than hybrid chickens on the free-range ($P < 0.05$), while village chickens in pen and those on the free-range showed a small difference of 3% ($P > 0.05$). The small difference could be linked to the natural instinct and ability of village chickens to scavenge under free-range. Slaughtered village chickens raised on the free range showed high content of insects in their crops. The insects included, grasshoppers, earthworms and fly larvae, while the hybrid contained mainly SFR diet. These insects are rich in protein ranging from 42% CP in fly larvae, 60%CP in earthworm to 76% CP in grasshoppers (Newton *et al.,* 1977; Gohl, 1981; Sugimura *et al*, 1984). Gohl, (1981) showed that the amino acid content of protein from insects was similar to that from fishmeal, an exceptionally good source of high quality protein. The better performance in village chickens on free range is supported by a good FER of 2.6 at 12 weeks compared with 4.2–3.0 in hybrid and village chicken in pen respectively. These findings agree with Ayorinde (1991) who reported poor feed conversion when local fowl in Nigeria were kept intensively. The FER of hybrid chickens decreased by approximately 54% from 8-12 weeks, while that of village chickens increased by 1.8%, with chickens on the free-range being more efficient (Table 2). The above argument is supported by differences in daily feed intake (Fig. 2) between village chickens on free-range and those in pens of 23% at 8 weeks and 34% at 12 weeks. It may be speculated that at 12 weeks, village chickens on the free-range were substituting concentrate diet for scavenged feedstuffs. It is reasonable to assume that being summer, the chickens were eating more insects as illustrated by the contents of the crop of slaughtered chickens. Thus, it may be suggested that compared with hybrid and village chickens at 8 weeks, village chickens utilize feed more efficiently at 12 weeks when they are allowed to scavenge on the free-range but given a concentrate diet as a supplement. However, the disadvantage of free-range is the fluctuation in the nutritive value and variability of feedstuffs, which may be influenced by the seasonal pattern. High performance of hybrid chickens observed in the current study is in accord with the standard practice of marketing hybrid chicken at 8 weeks, when efficiency of feed utilization is high. Beyond 8 weeks, profit is diminished due to inefficient feed utilization. On the other hand it may still be profitable to keep village chicken beyond 12 weeks due to the improved feed utilization efficiency. The slow growth in village chicken may be viewed as an advantage, which ensures regular supply of fresh meat to the household over a longer period. However, the subject is beyond the scope of the present study.

Carcass characteristics

The mean dressing percent in village chickens (60%) was low at 8 weeks compared with hybrid chickens (73%). But the differences tended to diminish at 12 weeks, being 66% and 69% in penned and free-range hybrids respectively and 65% in village chickens in pen and free-range. This could be in support of previous findings (Mupeta *et al.*, 2002) that up to 8 weeks of age, offal[6] in relation to carcass, grow at a high rate ($P < 0.05$) in village chickens compared with that in hybrid chickens. The carcass yield in village chickens (652-724 g) was low ($P < 0.05$) compared with hybrid chickens 1276-1712 g at 12 weeks and at 8 weeks 393-400 g and 1088 – 1348 g respectively. However, the quality of meat from village chicken appeared more favourable terms of higher protein (74%) and less carcass fat (33%) compared with 69% CP and 47-51% fat in hybrid. The higher protein in village chicken carcass is likely to be due the increased muscle development required for scavenging and at times flight (Ayorinde, 1991). Similarly, the lower percent body fat may be a consequence of the arboreal or feral mode of living. High dietary fat intake was linked to incidences of cardiovascular diseases and cancer and that high body fat deposition was associated with inefficient energy metabolism, representing an economic loss to the producer (Pasternak and Shaley, 1983).

Water consumption
Many factors are known to affect water intake: genetic, dietary salt concentration, source and concentration of dietary protein and physical form of the diet (mash or pellets; Marks, 1980). In the present study, hybrid birds in general consumed 74% more water than village chickens, with Hybrid in pen consuming 26% more water than those on the free-range, while village chickens in pen consumed 21% more water than those on the free-range. Water intake was related to feed consumption. Although hybrid birds consumed more feed and more water, no significant differences in water: feed ratios were found at 12 weeks between hybrid and village chickens. However, at 8 weeks, the water: feed ratio was significantly low in village chickens compared to hybrid chickens, being 1.6 – 1.7 in village chickens on free-range and in pen respectively and 2.1 – 2.2 in Hybrid chickens in pen and free-range respectively. Marks (1980) reported elevated water: feed ratio in broilers selected for high body weight. The reliability of the empirical rule suggests that a bird will drink twice the weight of its feed intake (National Research Council, 1977). This concurs with present study where, at 12 weeks water: feed ratio ranged from 1.8 – 2.2 in hybrid and village chickens.. Gardiner and Hunt (1984) reported water: feed ratio of 1.75 in the ninth week of meat–type chickens and showed a positive, correlation coefficient ($r^2 = 0.97$) between water and feed intake. Water intake is more dependent on the availability of feed than feed is on the availability of water (Marks and Brody, 1984). In Fig. 2, village chickens in pens and free-range showed high differences in water consumption of 29% and 26% at 8 and 12 weeks respectively compared with 20% and 5% between hybrid chickens at 8 and 12 weeks respectively. It may be speculated that the observed high differences between village chickens could be due to water economy, a survival mechanism developed by village chickens on the free-range.

The ability to estimate the amount of water consumption of growing chicks is important because water supply is a limiting resource among most of the smallholder farming areas especially those located in the marginal agro – ecological regions of Zimbabwe.

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[6] Offal = digestive tract, feet, head and neck

Management effect

Live weight, feed intake, water intake and mortality were used as indicators to evaluate management ability between farms. The effects of the different treatments for each of the indicators were pooled together in order to facilitate comparison. There were significant differences in management related to mortality, feeding, watering the chickens. However, differences in management approached significance at 5 and 12 weeks. Week 5 coincided with a change of diet from commercial starter to low-fibre SFR diet. Farm 4 experienced the highest mortality and consistently shows low management for all parameters. Farms 1, 5, 6, and 7 experienced zero mortality and appeared to apply reasonable management practices. Successful poultry management requires the application of factors including skills, labour, feed and water management, record keeping, aptitude, hygiene and health. Patullo, (1987) reported output between dairy farms to be influenced by differences in farmer's working knowledge of animal nutrition, disease and aptitude. Aptitude may be expressed as the ability of the farmer to decide on certain critical operations in order to take corrective measures before major problems arose. All the farmers kept records as a requirement to participate in the study, but the use of these records as a reference tool for budgeting and planning tended to vary with farm.

Profitability

Gross margin analysis and return per dollar invested were employed to evaluate the profitability of feeding low-fibre SFR diet. Gross margin in village chickens increased with age, being high at 12 weeks than 8 weeks, while gross margin in hybrid decreased. At 12 weeks, return per dollar from village chickens was significantly high ($P < 0.05$) compared with hybrid chickens. Up to 8 weeks, it was more profitable to feed hybrid chickens ($P < 0.001$) as both gross margin and return per dollar were significantly high compared with village chickens. Previous experiments showed similar results of hybrid out performing village chickens under improved management when a commercial diet was fed (Mupeta *et al.*, 2002). Village chickens on the free-range, but supplemented with low-fibre SFR diet showed superior gross margin and return per dollar compared with village chickens raised in pens. These results show that low-fibre SFR may be used as a viable option in poultry diets to feed both hybrid and village chickens in pen or as supplements on the free-range.

Conclusion

The present study revealed that the sunflower residue from local manually operated ram press machine, can be pressed through a sieve, 1.4 mm screen to obtain a low-fibre, high protein fraction. The low-fibre SFR may be used as a protein concentrate to formulate local poultry diets, which may avert the problem of limited supply of commercial poultry feeds in the smallholder farming areas. Hybrid chickens given a low-fibre SFR diet manifested their genetic superiority without adverse effects. Approximately 2000 g is reported in literature as the standard weight for normal growth of hybrid broilers at 8 weeks. Hybrid chickens raised in pens reached 2 425 g, which was higher than 2 000 g. Therefore, low–fibre SFR diet is a viable option for improving poultry production in the smallholder sector. It may be given to hybrid or village chickens with no adverse effects on performance. High mortality was experienced when hybrid chickens were raised on the free-range, the birds showed limited scavenging ability under temperature conditions of $\pm$ 23^{o}C, common in most of the drier areas in Zimbabwe. Village chickens are poor feed converters when kept in pens compared with free-range. However, the performance of village chickens improves with age, high feed efficiency, gross margin and return per dollar were experienced at 12 weeks. Another advantage is that of high body protein and low body fat. Considering this advantage, and taking into account the increasing demand by consumers for diets containing low levels of animal fat, there may exists a larger potential market for village chickens.

Based on low inputs and outputs, village chickens play a part in a balanced farming system with a unique role in the economy of the rural household, as a source of high protein for the family, provide small income and play part in the cultural life of the society.

Table 1. Chemical composition (g/kg DM) of feed ingredients and experimental diets fed to village and hybrid chickens raised in pens and on the free-range

FeedIngredient	FeedIngredient.(%)	CP	CF	EE	Ca	P	ME Mj/kg)	Methionine	Lysine
Sunflower residue	-	203	202	326	2	10	11.3	8.1	7.2
Diet IngredientsSieved SF fraction	30	231	145	322	2	10	11.6	8.3	7.3
Maize meal	48	80	36	40	0.2	2.5	14.2	3.6	2.7
Broiler concentrate	22	390	42	29	7.5	9	10.4	14	30
Experimental dietsLow-fibre SFR	100	196	69	121	6.1	8.7	12.4	0.76	1.04
Commercial starter	100	224	30	28	9.4	8.8	12.3	0.69	1.16

Table 2. Performance of hybrid and village chickens fed low-fibre SFR diet, raised in pens and free-range up to 8 and 12 weeks of age

Up to 8 weeks of age	**Hybrid chickens**		**Village chickens**			
Parameters	**Pen**	**Free-range**	**Pen**	**Free-range**	**s.e.m**	**Sig**
Live weight (g/bird)	2 425[a]	1955[b]	724[c]	703[c]	77.6	***
Feed consumption (g/bird)	6 305[a]	5 279[b]	2 317[c]	1 898[d]	176.8	***
Feed efficient ratio[7] (FER)	2.6[a]	2.7[a]	3.2[b]	2.7[a]	1.64	*
Water consumption (g/bird)	13704[a]	10910[b]	3995[c]	3 431[d]	260.9	***
Water: Feed ratio[8]	2.2[a]	2.1[a]	1.7[b]	1.6[b]	0.25	*
Up to 12 weeks of age						
	Hybrid chickens		Village chickens			
Parameters	Pen	Free-range	Pen	Free-range	s.e.m	Sig
Live weight (g/bird)	3 369[a]	2 538[b]	1 186[c]	1 054[c]	83.3	***
Feed consumption (g/bird)	13 476[a]	10 660[b]	3 558[c]	2 879[d]	192.5	***
Feed efficient ratio	4.0[a]	4.2[a]	3.0[b]	2.6[c]	1.05	*
Water consumption g/bird	29411[a]	20853[b]	6879[c]	5 178[d]	657.3	***
Water: Feed ratio	2.2[a]	2.0[a]	1.9[a]	1.8[a]	0.25	NS

NS, P>0.05; * P<0.05; ***P<0.001

[abcd] Values with different superscripts in the same row are significantly different.

[7] FER Feed intake: live weight gain ratio

[8] Water: Feed ratio = Relationship between water consumption to feed intake

Table 3. Carcass characteristics and nutrient composition (%) of lean in hybrid and village chickens raised in pens and on the free-range

	Hybrid chickens		Village chickens		
At 8 weeks	In Pens	Free-range	In Pens	Free-range	s.e.m
Plucked dead weight[9] (g)	1848	1478	668	657	56.6
[10]Dressing (%)	72.9	73.6	60.0	59.8	1.23
Bone (g)	252	201	104	102	2.3
Lean (g)	1096	876	296	291	5.7
DM	97.5	97.6	97.8	97.7	1.25
CP	69.2	69.5	74.3	73.9	2.91
EE	49.1	47.6	33.8	33.4	3.88
Ash	7.4	6.9	10.1	9.9	1.98
At 12 weeks					
Plucked dead weight (g)	2584	1860	1106	996	61.3
Dressing (%)	66.0	68.6	65.3	65.0	2.51
Bone (g)	309	230	180	162	3.1
Lean (g)	1403	1046	544	490	5.9
DM	97.4	97.5	97.3	97.4	1.23
CP	68.9	69.1	74.5	74.2	2.93
EE	51.4	51.1	34.0	33.8	4.24
Ash	8.3	8.6	10.3	10.2	2.31

[9] Plucked dead weight = live weight of bird (g) less the weight (g) of feathers.

[10] Dressing (%) = given as a percentage of carcass weight (live weight less feathers and offal (head, heart, lungs, liver, intestine, feet)

Table 4. Effect of farm (management) measured by performance of hybrid and village chickens in the study.

Live weight (g/bird/wk)					Farm number							
	1	2	3	4	5	6	7	8	9	10	s.e.m	Pr >F
4 weeks	368	360	356	336	364	355	356	348	359	358	10.0	***0.469***
5 weeks	641	685	505	413	666	589	689	557	631	642	83.4	***0.050***
8 weeks	1553	1525	1429	1280	1420	1518	1644	1566	1513	1498	98.4	***0.295***
12 weeks	2140	2101	1926	1696	2035	2178	2109	2061	2112	2054	117.8	***0.070***
Feed intake (g/bird/wk)					Farm number							
	1	2	3	4	5	6	7	8	9	10	s.e.m	***Pr >F***
5 weeks	753	779	514	537	580	487	520	378	501	496	74.2	***0.016***
8 weeks	963	1002	1012	842	974	1007	979	908	955	967	36.9	***0.05***
12 weeks	1170	1161	1208	1094	1166	1179	1188	1096	1168	1160	36.4	***0.597***
Water intake (g/bird/day)					Farm number							
	1	2	3	4	5	6	7	8	9	10	s.e.m	***Pr >F***
5 weeks	184	263	249	219	232	253	253	200	228	236	6.69	***0.001***
8 weeks	353	380	280	360	340	366	373	408	366	374	21.13	***0.021***
12 weeks	636	396	342	410	398	314	414	445	371	364	37.3	***0.001***
Mortality (%)	0.0	2.5^{a}	7.5^{a}	10.0^{a}	0.0	0.0	0.0	2.5^{a}	5.0^{c}	2.5^{a}	0.113	***0.041***

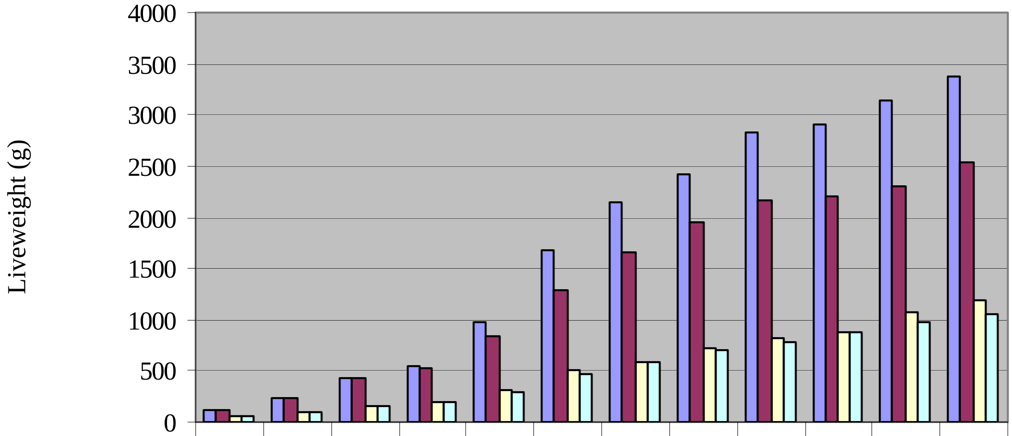
Table 5 Profitability of feeding low-fibre sunflower residue to hybrid and village chickens raised in pens and on the free-range at 8 and 12 weeks of age

	Gross Income (Z$/bird)	TVC (Z$/bird)	Gross margin (Z$/bird)	Return per $ invested
At 8 weeks of age				
Hybrid birds in pens	2 182[a]	1 225[a]	957[a]	1.80[a]
Hybrid birds free-range	1 760[b]	1 071[b]	689[b]	1.60[b]
Village birds in pens	688[c]	525[c]	163[c]	1.30[c]
Village birds free-range	668[c]	430[d]	238[d]	1.55[b]
s.e.m	168.3	149.1	46.9	0.07
CV%	38.3	50.9	32.2	15.5
Pr > F	*0.001*	*0.016*	*0.001*	*0.001*
At 12 weeks of age				
Hybrid birds in pens	3 032[a]	2 334[a]	698[a]	1.30[a]
Hybrid birds free-range	2 284[b]	1 904[b]	380[b]	1.2[a]
Village birds in pens	1 127[c]	763[c]	364[c]	1.48[b]
Village birds free-range	1 001[d]	621[d]	380[c]	1.61[b]
s.e.m	66.9	45.7	76.1	0.044
CV	10.2	9.3	46.5	9.2
Pr > F	*0.001*	*0.001*	*0.001*	*0.046*

[Abc] Means in the same column with different superscripts differ significantly P < 0.005

Gross Income = X*Y
Gross Margin = (X*Y) – (TVC)
Return per dollar invested = Gross Income/ TVC)
X = Live weight of chickens (kg)
Y = Price of chickens $/kg ($900 and $950 hybrid and village birds respectively)
TVC = Total variable costs (Costs directly related to production of chickens e.g. feed, water, labour)
CV Co efficiency of variation
s.e.m standard error of mean

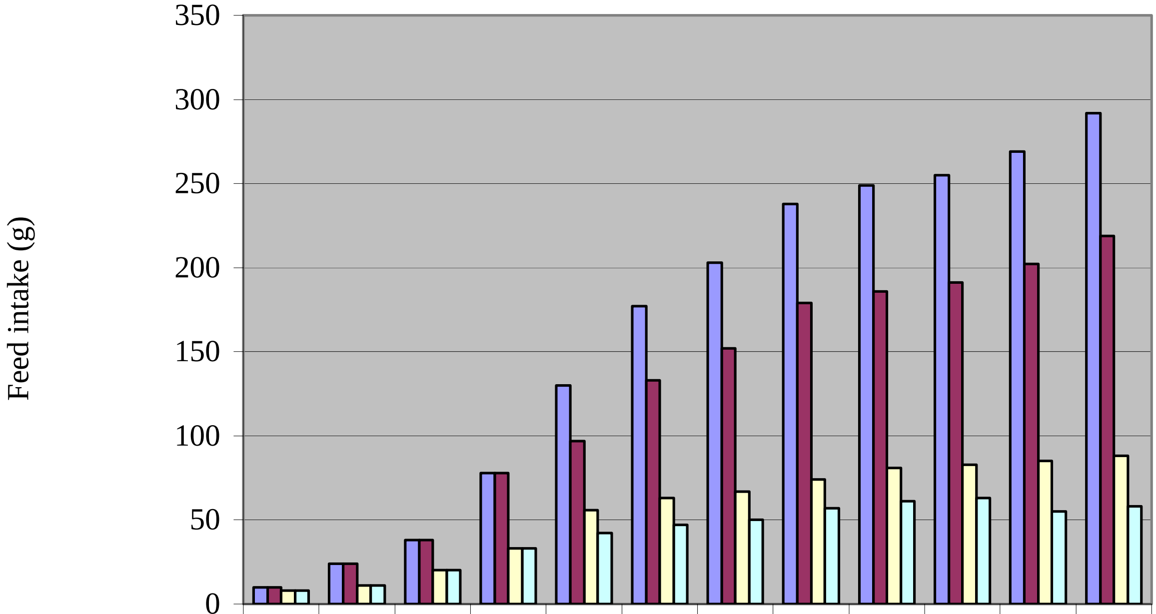
Figure 1. Liveweght (g/wk) of hybrid and village birds raised in pens and free-range fed low fibre SFR diet



	1	2	3	4	5	6	7	8	9	10	11	12
Pen Hybrid	110	242	439	537	971	1683	2145	2425	2834	2910	3134	3369
Free hybrid	110	242	439	520	842	1288	1660	1955	2170	2211	2298	2539
Pen village	58	89	148	189	318	513	585	724	820	876	1075	1186
Free village	58	89	148	192	291	459	581	703	790	883	984	1054

Age in weeks

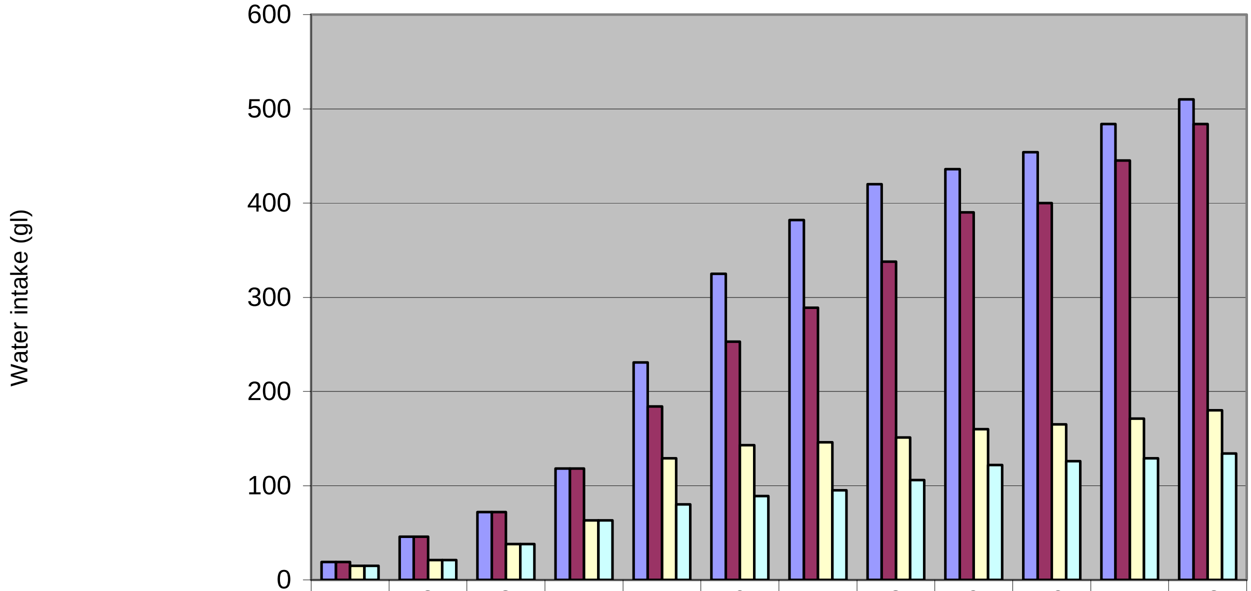
Figure 2. Feed intake (g/d) of hybrid and village chickens given low- fibre sunflower residue diet and raised in pns and free-range



	1	2	3	4	5	6	7	8	9	10	11	12
Pen hybrid	10	24	38	78	130	177	203	238	249	255	269	292
Free hybrid	10	24	38	78	97	133	152	179	186	191	202	219
Pen Village	8	11	20	33	56	63	67	74	81	83	85	88
Free Village	8	11	20	33	42	47	50	57	61	63	55	58

Age in weeks

Figure 3. Weekly water intake (g/d) in hybrid and village chickens raised in pens and free-range



	1	2	3	4	5	6	7	8	9	10	11	12
Hybrid in pens	19	46	72	118	231	325	382	420	436	454	484	510
Hybrid on Free-range	19	46	72	118	184	253	289	338	390	400	445	484
Village in pens	15	21	38	63	129	143	146	151	160	165	171	180
Village on Free-range	15	21	38	63	80	89	95	106	122	126	129	134

Age in weeks

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Output 6: Workshop for dissemination of research findings

The prevailing political situation in Zimbabwe militated against an international workshop. However, a very successful field-day was hosted by the ten female farmers who managed the on-farm poultry study, in collaboration with Agriculture Research and Extension (AREX) staff. As well as disseminating the results of their study to friends and neighbours, the farmers successfully described their results to some six hundred farmers who attended the field day. The Concern Zimbabwe Trust has also expressed its desire to exploit sunflower oilcake as part of its programme to promote the commercial production of milk. Although this project did not explicitly address the feeding of dairy cattle, much of the data generated will be of interest to the Trust. The key counterpart in this project, Dr Bart Mupeta, was also invited to present his studies on the use of sunflower seed cake in poultry diets at the Ninth Regional Conference of the Southern and Eastern Africa Association for Farming Systems Research-Extension, held in Uganda on 29 September to 3 October 2003.

Contribution of Outputs

The outputs of the project have been mostly achieved and generated knowledge that will enable oilseed processors, and poultry & small ruminant producers, to make informed decisions on the utilisation of ram press-produced sunflower oilcake in livestock diets. The outputs clearly demonstrated the viability of using sunflower seed cake in the diets of both hybrid and indigenous poultry, under village-level management. The viability of successfully incorporating sunflower oilcake into small-ruminant diets will depend upon the ability of technologists to improve the oil-extraction efficiency of the ram-press. Sunflower oil-cake produced during this project had an excessive oil content that compromised the efficacy of the resultant goat diet.

Undoubtedly, the appropriate exploitation of sunflower products (oil and cake) will make a significant contribution to the improvement of the health and livelihood of small farmers.

Future studies should focus upon the validation and dissemination of low-cost, sunflower cake-based diets for poultry, small ruminants, dairy cattle and draught animals. There is also a need for parallel activities to develop and promote appropriate procedures for the production of sunflower crops, the oil extraction of sunflower seeds and simple sieving technology for the production of low fibre diets.

Publication (other publications are under preparation)

MANDONGA, F. (2002) The performance characteristics of broiler feeds based on sunflower oilcake, with reduced fibre level, for use in peri-urban and rural poultry systems. MSc thesis. Natural Resources Institute, University of Greenwich, Chatham, UK (submitted)