The added value of sunflower: performance of indigenous chicken fed a reduced-fibre sunflower cake diet in pens and on free-range

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Abstract

The value of Sunflower (SF) was increased by expelling oil from whole SF seed and the defatted cake used in formulating poultry diets. The SF residue was then sieved through a 1.4 mm screen to retain the coarse higher fibre fraction, while the reduced-fibre sunflower cake passed through the screen. Reduced-fibre sunflower cake included in the diet is a viable option for improving production in smallholder-owned poultry. Two hundred indigenous chicks were given broiler starter from1-28 days followed by a reduced-fibre sunflower cake diet (29-84 days). On day 29 the chicks were randomly allocated to two treatments: indigenous chickens in pens or on free range. The trial was replicated on 10 farms and managed by women. Weight gain increased with age from 0.72 kg and 0.70 kg at 8 weeks for chickens in pens and on free-range respectively to 1.19 kg and 1.05 kg at 12 weeks ($P<0.05$). The breast meat tissue of the indigenous chickens was high in crude protein (CP, 740 g/kg) and low in ether extract (EE, 330 g/kg). At eight weeks, feed efficiency ratio in free-range chickens (1:2.7) was better than indigenous chickens in pen (1:3.2). Interestingly, at 12 weeks, there was an improvement in feed efficiency ratio (1:3.0 for chickens in pens and 1:2.6 for he chickens on a free-range) ($P<0.05$). A low water: feed ratio was observed in indigenous chickens (1:1.6 free-range, 1:1.7 penned) at 8 weeks and 1:1.9 in penned and 1:1.8 in free-range chickens at 12 weeks. At 8 weeks the gross margin per bird of indigenous chicken ([1]equivalent US$ 0.54-0.79) was low compared to 12 weeks (US$ 1.21-1.27). Return per dollar of indigenous chickens in pens (1.30) was lower than indigenous chickens on free-range (1.55). At 12 weeks, return per dollar significantly improved (1.48–1.61) in indigenous with greater improvement in chickens on the free-range.

Key words: reduced-fibre sunflower cake, indigenous chicken, free-range, value added, feed efficiency

Introduction

Feed constitutes approximately 75 per cent of the variable costs in poultry production. The demand for low-cost poultry feed is high, due to the rising cost and limited supply of commercial feeds. Sunflower (*Helianthus annus*) is a potential source of protein in poultry diets. It is high in fibre, rich in cystine and methionine (sulphur containing amino acids),

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[1] Equivalent exchange rate: 1US$ to Z$300, March 2003

but low in lysine. The high fibre content limits the utilization of the sunflower residue in poultry (Smith, 1968). The presence of high fibre and associated polyphenolic compounds (chlorogenic acid), in sunflower hulls limit intake and digestibility and may cause adverse effects on poultry performance (Singleton and Kratzer, 1969). However, passing sunflower seeds, after extraction of oil, through a 1.4 mm screen produced low-fibre sunflower residue, which resulted in a feed that improved poultry performance (Mupeta, *et.al.*, 2001).

The demand for vegetable oil in Zimbabwe exceeds output from the commercial processing industry. 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 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 farmers (Hikwa and Whingwiri, 1986). This was based on the understanding 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.

The potential of value added sunflower and of feeding reduced-fibre sunflower cake on performance of indigenous chickens raised in pens and on free-range has not been evaluated on-farm. Therefore, the objective of the present study was to evaluate the potential of reduced-fibre sunflower cake, included in poultry diets, on the performance of indigenous chickens, raised in pens and on free-range, managed by women farmers at the household level.

Materials and methods

Three hundred and fifty eggs (1-7 days old) were collected from indigenous chickens. The eggs weighing 23 ± 1.6 g were kept at room temperature for 24 hours and then transferred to an incubator. 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 per cent hatchability).

Two hundred chicks (38 ± 1.5 g) were divided into eight groups of 25 chicks and transferred to eight brooder boxes and reared for 28 days. Broiler starter feed and water were offered *ad libitum* to the chicks during this period. The brooder boxes, measuring 6 m^2 with mesh floors and raised 20 centimetres above ground, were housed in a thatched house. Natural light was used in the daytime, with no supplementary lighting at night during brooding. On day 29, the chicks were randomly allocated to two treatments, which were replicated at 10 households, and managed by women. The treatments were indigenous chicks in pens and indigenous chicks on free range. Free-range is defined as scavenging for food; indigenous chickens are village chickens). The reduced-fibre sunflower cake diet was offered *ad libitum* to chickens raised in pens (29-84 days), while those on free-range received 75 per cent of the weekly intake of chickens on *ad libitum*. The finisher diet consisted of reduced-fibre sunflower cake (SFC), broiler concentrate and maize meal, in the ratio 0.3: 0.12: 0.58 respectively.

A hand operated ram press was used to expel the oil from the whole sunflower seed. Here, a reciprocating piston delivered the seed to the compression chamber, where the same piston at high pressure compressed it. After compression, the oil escapes from the chamber. The defatted sunflower cake is then forced out of the chamber against an adjustable cone that restricts the flow of cake and maintains pressure within the chamber. Approximately 600 kg of oil and 1,800 kg cake were obtained from 2,500kg of sunflower seed. The sunflower cake was then passed through a 1.4 mm sieve to separate the reduced-fibre, high protein fraction from the high fibre, low protein fraction. The reduced-fibre sunflower cake was used as a protein source in the poultry diet. The maize meal was a product of maize grain, milled through a 1.0 mm screen using a hammer mill. 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. 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 wide, were filled with clean water each morning. Feed troughs were cleaned and filled with feed once per week, while the birds were being weighed.

Measurements

Chickens were weighed weekly, on the same day and time, using a hanging balance scale. Daily feed intake was recorded as the difference between feed offered and feed remaining in the feed hopper. Daily water intake was the difference between water offered and left. Daily temperatures were recorded at 0600h, at 1200h and at 1800h. The carcass composition was analysed in two chickens from each of the treatments, slaughtered at 8 and 12 weeks. Dressing percentage, lean, bone, and protein and fat of meat content were measured. Profitability was calculated from prevailing variable 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 procedures of AOAC (1990), dry matter (DM), crude protein (CP; N x 6.25), crude fibre (CF), ether extract (EE), calcium and phosphorus (Table1. Metabolisable energy contents (ME) of the diets were calculated from the chemical analysis data using pre-established formulae (Wiseman *et al.,* 1991). ME (kcal/kg) = $4.26X_1 + 9.5X_2 + 4.23X_3 + 4.23X_4$

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

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).

Results

Feed

Table 1 shows the chemical composition of the feed ingredients, commercial starter and SFC diets. Compared with the unseived sunflower cake, the reduced-fibre SFC fraction contained 28 per cent less fibre and 14 per cent 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). Protein content of the SFC diet (16.8 per cent) approached the lower limits of 17 - 18 per cent recommended for hybrid broilers (29-56 days) (NRC, 1977). The SFC diet was high in fibre (6 per cent) and oil (9 per cent) compared to levels of 5 per cent fibre and 3 per cent fat, formulated by Agrifoods (Pvt) Ltd, a commercial feed manufacturing company in Zimbabwe.

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Table 1 *Chemical composition (g/kg DM) of feed ingredients and experimental diets fed to indigenous chickens raised in pens and on free-range (see text for details)*

Feed Ingredient	Ingredient (%)	CP	CF	EE	Ca	P	ME	Methionine	Lysine
SFC		203	202	326	2	10	11.3	8.1	7.2
Diet Ingredients									
Sieved SFC fraction	30	231	145	322	2	10	11.6	8.3	7.3
Maize meal	58	80	36	40	0.2	2.5	14.2	3.6	2.7
Broiler concentrate	12	390	42	29	7.5	9	10.4	14	30
Experimental diets									
Reduced-fibre SFC	100	168	59	91	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

CP = crude protein; CF = crude fibre; EE = ether extract; ME = metabolisable energy (Mj/kg DM)

Table 2 revealed that indigenous chickens in pens generally consumed 18 per cent more feed at 8 weeks and 19 per cent at 12 weeks than indigenous chickens on free-range ($P<0.05$). The chickens in pens obtained all their feed requirements from the home - mixed diet, while those on free-range obtained 25 percent of their feed from scavenging. Birds on free-range showed improved feed efficiency and tended to show favourable water : feed ratio compared to those in the pens.

Table *2 Performance of indigenous chickens fed a reduced-fibre sunflower cake (SFC) diet, raised in pens or free-range up to 8 and 12 weeks of age*

Age	**Up to 8 weeks**		**Up to 12 weeks**		
Parameters	Pen	Free-range	Pen	Free-range	s.e.m
Live weight (kg/bird)	0.72[a]	0.70[a]	1.19[b]	1.05[b]	0.134
Feed consumption (kg/bird)	2.32[c]	1.9[d]	3.56[e]	2.88[f]	0.36
Feed efficiency ratio[1]	3.2[a]	2.7[b]	3.0[a]	2.6[b]	0.15
Water consumption (L/bird)	4.0[c]	3.43[d]	6.88[e]	5.18[f]	0.609
Water: Feed ratio[2]	1.6[a]	1.5[a]	1.9[c]	1.8[c]	0.25

[abcd] Values with different superscripts in the same row are significantly different. ($P<0.05$)

[1] FER Relationship between feed intake and live weight gain

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

Water

Indigenous chickens, confined in pens consumed more water than indigenous chickens on free-range ($P<0.05$), the difference being 14 per cent and 25 per cent at 8 and 12 weeks, respectively (Table 2). The water: feed ratio varied with age, being significantly higher ($P<0.05$) at 12 weeks compared to 8 weeks.

Live weight

The differences in live weight at the same age of indigenous chickens in pens and those on free-range were small ($P>0.05$), being 3 and 11 per cent at 8 and 12 weeks respectively (Table 2). However, Chickens on free-range showed a better feed efficiency ratio than those, which were confined in pens.

Carcass quality

Carcass characteristics of indigenous chickens are given in Table 3. Plucked dead weight and dressing percentage of chicken raised either in pens or on the free-range were similar (P>0.05) and tended to vary with age ($P<0.05$). The difference in meat yield at 8 was small 3 percent and 9 percent at 12 weeks (P>0.05). The quality of breast meat tissue in terms of crude protein, fat (ether extract) and minerals (ash) of indigenous chickens either raised in pens or o the free-range was similar ($P>0.05$).

Table 3 *Carcass characteristics (kg) and nutrient composition (g/ kg DM) of lean in indigenous chicken raised either in pens or on free-range*

	At 8 weeks		At 12 weeks		
	In Pens	Free-range	In Pens	Free-range	s.e.m
Plucked dead weight[1]	0.67	0.66	1.11	1.00	0.266
Dressing[2] %	60.0	59.8	65.3	65.0	1.23
Bone	0.10	0.10	0.18	0.16	0.023
Lean	0.30	0.29	0.54	0.49	0.057
Dry matter (DM, g/kg)	978	977	973	974	4.5
Crude protein	743	739	745	742	9.1
Ether extract	338	334	340	338	18.8
Ash	101	99	103	102	11.8

[1] Plucked dead weight = live weight of bird less the weight of feathers

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

Table 4 *Profitability of feeding a reduced-fibre SFC to indigenous chickens raised in pens or free-range at 8 and 12 weeks of age*

Comment: Nos needed to footnotes

Age	**At 8 weeks**		**At 12 weeks**		
	Birds raise in pens	Birds raised on free-range	Birds raise in pens	Birds raised on free-range	CV%
Gross Income* ([1]US$ equiv/bird	2.29^{c}	2.23^{c}	3.76^{c}	3.33^{d}	10.2
TVC** (US$ equiv/ bird)	1.75^{c}	1.43^{d}	2.54^{c}	2.07^{d}	9.3
GM*** (US$ equiv/ bird	0.54^{c}	0.79^{d}	1.21^{c}	1.27^{c}	46.5
Return per $ Invested****	1.30^{c}	1.55^{b}	1.48^{b}	1.61^{d}	9.2

^{abc} Means in the same row with different superscripts differ significantly (P<0.005)

*Gross Income = X*Y [X= Live weight (kg), Y= Price of chicken Z$900/kg]

***GM = Gross Margin = (X*Y) – (TVC)

****Return per dollar invested = Gross Income/ TVC)

**TVC = Total variable costs (Costs directly related to production, e.g. feed, water)

CV = Co efficient of variation

[1] Equivalent exchange rate: 1US$ to Z$300, March 2003

Profitability

The profitability of feeding a reduced-fibre SFC diet to indigenous chickens raised either in pens or on free-range is given in Table 4. Indigenous chickens on free-range showed a high gross margin ($P<0.001$) compared with indigenous chickens raised in pens. Returns per dollar invested increased with age, with chickens on free-range showing a significantly higher return per dollar invested ($P<0.05$) compared with the chickens, which were confined in pens.

Discussion

In the present study, the reduced-fibre SFC diet was given to indigenous chickens raised in pens or on free-range, and managed by 10 women at their homesteads in Zimbabwe. The reduced-fibre diet was achieved by passing SFC through a 1.4 mm screen to recover the reduced-fibre, high protein fraction for inclusion in poultry diets. Reduction in fibre content was important, since fibre causes negative utilisation of energy. Chlorogenic acid, a phenolic compound found in association with the seed hulls of sunflower fibre is known to interact with the amino group of lysine and thus decrease its availability (Luhaloo, 1996). Directly substituting commercial broiler concentrate with reduced fibre sunflower cake was found to have no significant effect on feed intake by the indigenous chickens. The substitutions were able to reduce the feed costs of producing each kilogram of the live weight by up to 17% whilst production remained profitable with a farmer having the potential of making at least US$1.61 for each dollar invested in poultry production on free range.

Live weight

Indigenous chickens are genetically slow growing and tend to have low mature body weight with the limits of their performance rapidly reached when feeding and management were improved. Indigenous chickens in pens and those on free-range showed small differences ($P>0.05$) in live weight. The small difference could be linked to the natural instinct and ability of indigenous chickens to scavenge under free-range. Indigenous chickens raised on free range showed a high content of insects in their crops after slaughter, including grasshoppers, earthworms and fly larvae, while the crops of the indigenous chickens in pens contained mainly the SFC diet. These insects are rich in protein ranging from 42 per cent CP in fly larvae, 60 per cent CP in earthworms to 76 per cent 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 of fishmeal, an exceptionally good source of high quality protein. The better performance in indigenous chickens on free range is supported by a good FER at 12 weeks compared with indigenous chickens in pen. These findings agree with Ayorinde (1991), who reported poor feed conversion when local fowl in Nigeria were kept intensively. The FER of indigenous free - range chickens was better than the chickens that were confined in pens (Table 2). This is supported by difference in daily feed intake between indigenous chickens on free-range and those in pens of 23 per cent at eight weeks and 34 per cent at 12 weeks respectively. It may be speculated that at 12 weeks, indigenous chickens on free-range were substituting the 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 crops of slaughtered chickens. Thus, it may be suggested that indigenous chickens utilise feed more efficiently when they are allowed to scavenge on free-range and 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 effects. However, it may still be profitable to keep indigenous chickens beyond 12 weeks due to the improved feed utilisation efficiency. The slow growth in indigenous chickens may be viewed as an advantage, as it ensures a regular supply of fresh meat to the household over a longer period. However, this subject is beyond the scope of the present study.

Carcass characteristics

The quality of breast meat tissue of indigenous chicken appeared more favourable in terms of high protein and less fat. The high protein in indigenous chicken breast meat tissue is likely to be due the increased muscle development required for scavenging and, at times, flight (Ayorinde, 1991). Similarly, the low percentage of body fat may be a consequence of the arboreal or feral mode of living. High dietary fat intake is linked to incidences of cardiovascular disease and cancer and high body fat deposition is 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 (Marks, 1979). In the present study, indigenous chickens in pens consumed 21 per cent more water than those on free-range. Water intake was related to feed consumption. However, the water: feed ratio was not significantly different. The reliability of the empirical rule suggests that a bird will drink twice the weight of its feed intake (NRC, 1977). This concurs with the present study, where at 12 weeks the water: feed ratio approached 2.2 in indigenous chickens. Gardiner and Hunt (1984) reported a water: feed ratio of 1.75 in the ninth week of feeding in meat–type chickens and showed a positive, correlation between water and feed intake. Water intake is more dependent on the availability of feed than feed intake is on the availability of water (Marks and Brody, 1984). It may be speculated that the observed difference between indigenous chickens could be due to water economy, a survival mechanism developed by indigenous chickens on 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.

Profitability

Gross margin analysis and return per dollar invested were employed to evaluate the profitability of feeding a reduced-fibre SFC diet. Gross margins in indigenous chickens increased with age, being higher at 12 weeks than eight weeks. Indigenous chickens on free-range, when supplemented with a reduced-fibre SFC diet showed superior gross margins and returns per dollar compared with indigenous chickens raised in pens. These results show that reduced-fibre SFC may be a viable option in poultry diets to feed indigenous chickens in pens or as supplements on free-range. Sunflower was value added when the farmers earned approximately two to three times more gross income when they expressed sunflower oil at home compared to selling the sunflower seed to large processing companies or marketing boards. Sunflower seed at the Marketing Board fetched Z$261000 (approximately US$87) per metric tonne, while extracting sunflower oil at home produced approximately 200 litres of oil with a value of Z$654000 (approximately US$216) with additional benefit obtained from the use of sunflower cake in poultry diet formulation.

Conclusion

As a result of this study, it was considered that reduced fibre sunflower cake had the potential for 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. Indigenous chickens are poorer feed converters in pens than on free-range. However, the performance of indigenous chickens improved with age, with improved feed efficiency, gross margin and return per dollar at 12 weeks compared to eight weeks. The meat of indigenous chicken contains more protein and less fat than the meat of hybrid chickens (Mupeta, *et.al.,* 2002), indicating possible market advantages for indigenous chicken.

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