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The use of dried bakery products in a free-choice feeding method for small-scale broiler production

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ABSTRACT

Waste material from bakeries is an unconventional energy feed source which is available in sufficient quantities for use in small-scale broiler production in South Africa. Small-scale broiler producers do not have access to the computer programs required to balance home-mixed rations. This investigation confirms that the use of dried bakery products (DBP) in a 2-stage, free-choice method can be used to compensate for this lack. A total of 570 day-old male broiler chickens was assigned to 3 feeding treatments: the control group was fed a 2-stage feeding programme using standard commercial starter and grower rations. The 2nd group received a commercial starter ration up to Day 7 and was thereafter given a choice of a commercial starter ration with normal salt content (0.35 %) and DBP. The 3rd group was fed a commercial starter ration up to Day 7, then offered a choice of commercial starter ration with a lower salt content (0.1 %) and DBP. The low salt alternative was used to test whether the higher salt percentage in DBP influenced the choice of feed by the birds. It was found that the control group consumed significantly more feed ($P < 0.05$) and was significantly heavier ($P < 0.05$) than the experimental groups. However, there was no significant difference between the 2 experimental groups, which indicated that salt content did not play a role in the choice of ration. Feed consumption by both experimental groups was about one-third less than the control group, but the profit margin, as calculated using gross margin analysis, was approximately 15 % higher. It was therefore concluded that dried bakery products can be profitably incorporated as an energy feed source, using the free-choice feeding method, in small-scale broiler enterprises.

Key words: broilers, dried bakery products, economics, energy feed source, free-choice feeding, salt content, small-scale farmers.

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INTRODUCTION

Veterinarians and animal health technicians are involved in extension to small-scale farmers in South Africa. This extension includes advice on appropriate and cost-effective nutrition. Small-scale poultry farming offers an opportunity for sustainable food production and job creation in developing countries.

In most developing countries, cereals such as maize are a major staple food for human consumption, but production may be insufficient to allow surplus for small-scale poultry production. When the cost of commercial rations becomes prohibitive, however, non-traditional sources of energy feed should be sought.

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Waste material from bakeries is a potential unconventional energy feed source available in sufficient quantities for use in small-scale broiler production in South Africa. The American Association of Feed Control Officials recognises this ingredient under the official name of 'dried bakery product' (DBP)[13,14]. DBP is a mixture of surplus and unsaleable materials collected from bakeries. The various products are collected, ground, mixed, and dried to a moisture content of approximately 10 %[13,14]. Several authors have suggested that it may be an acceptable feed ingredient in broiler rations[5,7].

Small-scale farmers lack the sophistication to properly mix rations and do not have access to personal computer programs to aid them. A practical way of balancing a variety of feed ingredients in a ration, however, is by employing the 'choice feeding method' (CFM). CFM allows domestic animals to balance their own diet by free access to protein/vitamin/mineral concentrates and an energy source such as whole grain[1,9,10].

Using CFM, variability in the nutritional contents of different DBP batches can be overcome, since animals tend to adjust their diet appropriately[9].

This study was designed to evaluate the economic aspects of including DBP as a CFM energy feed source. Data were recorded on weekly feed intake, body-weight gain and mortality, and used to calculate the feed conversion rate (FCR). Feed cost analysis, net profit (NP), total production cost (TPC), gross margin analysis and total variable costs (TVC) were also performed.

MATERIALS AND METHODS

The experiment was conducted in a environmentally controlled broiler house with wood shavings over concrete. In total, 570 day-old, male broiler chicks (Ross) were used in this experiment. The chicks (38 birds per pen) were randomly assigned to 15 pens, each with a floor area of 1.8 m^2 (calculated from a recommended stocking density of 21 adult birds/m^2). Each pen contained 2 tube-feeders, and 3 drinking nipples (optimal supply of water is 1 nipple drinker per 15 birds). Heating was provided by 1 ceramic heater per 3.6 m^2 floor area.

Chicks were fed on a complete commercial starter diet in mashed form during the 1st 7 days. Free access to feed and water was allowed during this period. On Day 7, the birds were individually weighed using an electronic scale accurate to the nearest gram (Richter, model KA-10). The experimental period started when the broilers were 7 days old. Three dietary treatments were each assigned to a block of 5, *i.e.* each treatment was replicated 5 times. A randomised block design was used to minimise variable house effects.

The 3 dietary treatments were (Tables 1–3):

- Treatment A (Group TA): normal commercial feed in 2 feeding phases: commercial starter ration (mash) from Days 1 to 21. This commercial starter was the same as that of S1 (see below). A commercial grower ration (pellet) was given from Days 22 to 42. This treatment served as the control.

- Treatment B (Group TB): normal commercial starter ration (mash) for the 1st 7 days, followed by a starter ration with a normal salt content (S1) plus DBP1 from Days 8 to 42, using CFM. S1 contained 0.35 % salt.
- Treatment C (Group TC): normal commercial starter ration (mash) for the 1st 7 days, followed by a starter ration with a lower salt content (S2) plus DBP2 from Days 8 to 42, using CFM. S2 contained 0.1 % salt.

DBP1 and DBP2 were identical but they were assigned a specific identity to facilitate discussion on differences in feed intake between Groups TB and TC. The composition of the commercial grower ration used in Group TA, the starter rations used in Groups TB and TC, as well as their calculated nutritive values, are shown in Tables 1–3.

In pens where dietary choices were provided, the 2 rations were randomly assigned to the 2 feeders. The feeding space for broilers was based on a recommended 30 feeders per 1000 birds (one feeder per 30 birds). Feeding space was, therefore, adequate, as there were 2 feeders per 38 birds. For the 1st 7 days the commercial starter ration was was placed in both feeders (all groups). Once CFM began, DBP was placed in 1 feeder and TB (treatment with normal salt content) or TC (treatment with low salt content) in the other feeder. TA (control) was placed in both feeders. The brooding temperature started at 32 °C and was gradually reduced to 30 °C over the 1st 4 days and then to 22 °C by Day 21.

Observation/analytical procedures

As farming becomes more and more business orientated, greater demands are made on the financial and technical abilities of farmers. For these reasons, we considered the economic and technical aspects of the study separately.

Economic efficiency

The following basic economic analyses were done to determine the cost-effectiveness of substituting DBP for maize according to the economics of commercial production[2,3,8,12]:

- Cost analysis of the 3 treatment groups (TA, TB and TC).
- Total production cost (TPC), total revenue (TR) and net profit (NP):
  - TR = (price per kg × total weight of live birds per treatment on Day 42 × meat yield). Average meat yield after slaughter was 70 %.
  - TPC = total fixed costs + total variable costs.
  - NP = TR–TPC.
- Gross margin analysis and total variable costs (TVC).

The gross margin for each farm enterprise is the difference between the income (value of output) and the direct (variable) costs associated with the enterprise. The gross margin represents the contribution of the enterprise towards paying the fixed (overhead) costs of the farm. The total (sum) of the gross margins of the various farm enterprises minus the fixed (overhead) costs of the farm gives the net profit[2].

Technical efficiency

Technical efficiency was measured in terms of feed intake, body weight, feed conversion and mortality:

- Feed intake (kg): the cumulative and weekly feed intake were calculated every week, and the average cumulative and weekly feed intake per bird were determined for Groups TA, TB and TC.
- Body weight (kg): all the birds were individually weighed on Days 7, 14, 21, 28, 35 and 42. Average body weight per bird was determined for Groups TA, TB and TC.
- The feed intake and body weight were measured to the nearest gram.
- Feed conversion was calculated at the end of the experiment using the following formula[11]:

$$\frac{\text{Total feed consumed in kg per treatment on Day 42}}{\text{Total body weight in kg per treatment on Day 42}}$$

- Mortalities were recorded every day. Percentage mortality for each diet was calculated, and data for Groups TA, TB and TC were compared statistically.

Data analysis and statistics

Data were entered into a spreadsheet (Excel®, Microsoft Corporation, Redmond), and differences between treatments A, B and C assessed by analysis of variance (ANOVA).

The confidence interval was taken at the 95 % level ($P = 0.05$), assuming body weight ranged between 1.9 and 2.5 kg per broiler by Day 42, with a common standard deviation of 0.28 kg. For a power of 90 % and sample sizes of 176 and 200 per group, an effect of 0.156 kg and 0.146 kg, respectively, would be considered significant at a confidence interval of 95 % ($P = 0.05$). This resulted in little differences in the weight of birds, as an effect

Table 1: **Composition of commercial grower ration used in Group TA, and starter rations, S1 and S2, used in Groups TB and TC, respectively.**

Ingredient	Grower ration	Starter 1 (S1)	Starter 2 (S2)
1. Yellow maize (8.0 %)	68.90	60.59	60.74
2. Milling by-product	4.50		
3. Bran (15 %)	1.49	1.99	
4. Local fish meal	4.97	4.98	
5. Soya oil cake (47 %)	9.00	24.83	24.40
6. Sunflower oil cake (38 %)	13.00	4.97	4.98
7. Choline chloride liquid	0.08		
8. Lysine HCL	0.11	0.11	
9. DL-methionine	0.17	0.17	
10. L-threonine	0.09	0.09	
11. Synthetic amino acid	0.58		
12. Monocalcium phosphate	1.80	0.79	0.80
13. Limestone	1.53	1.39	1.39
14. Salt	0.32	0.35	0.10
15. Vitamins and medicines	0.20	0.25	0.25
Total	100.00	100.00	100.00

Table 2: **Calculated nutritive value of commercial grower ration used in Groups TA, and starter rations, S1 and S2, used in Groups TB and TC, respectively.**

Nutrient	Unit	TA	TB	TC
ME* poultry	MJ/kg	12.70	12.50	12.50
Crude protein	g/kg	190.00	220.31	219.27
Lysine	g/kg	10.50	12.81	12.74
TSAA*	g/kg		9.22	9.20
Tryptophan	g/kg		2.58	2.57
Fat	g/kg	39.80	35.41	35.60
Fibre	g/kg	58.70	36.02	36.41
Calcium	g/kg	9.00	10.24	10.26
Total phosphorus	g/kg	7.30	6.94	6.97
Available phosphorus	g/kg	4.20	4.47	4.48
Sodium	g/kg	1.9	1.95	1.01

*ME = metabolisable energy; TSSA = total sulphur amino acids.

of 0.10 kg was regarded as small, 0.25 kg as medium and 0.4 kg as large. Accurate weighing of birds was therefore important.

A sample size of 190 birds per group was indicated and the effect decreased to 0.10, the power dropped to 58 % ($P < 0.05$), which was acceptable. Under the above assumption a small difference between the 3 groups was identified.

Table 3: **Composition of dried bakery products (DBP).**

Nutrient	As is 'basis'	Dry-matter basis
Dry matter (%)	90.40	100.00
Moisture (%)	9.60	0.00
Ash (%)	2.70	2.90
Brute energy (MJ/kg)	16.10	16.10
Crude proteine (%)	12.70	14.10
Crude fiber (%)	0.50	0.50
Fat (%)	1.10	1.20
Calcium (%)	0.09	0.10
Phosphorus (%)	0.13	0.14
Sodium (mg /kg)	4578.00	5085.00

RESULTS AND DISCUSSION

Feed intake, body weight, feed conversion rate and mortalities

Table 4 presents the mean and standard deviation of body weight, feed intake, feed conversion rate and mortality of Groups TA (control) TB and TC at different ages in days.

Although the cumulative feed intake of birds in Groups TB and TC equalled that of the control (TA) by Day 21 and Day 28, respectively, the mean body weight of birds in TB and TC remained lower than in TA. There was no significant difference in weight gains between TB and TC after the inclusion of DBP, despite the difference in the salt content. At the end of the experiment (Day 42) the birds in TA were 0.224 kg (10.3 %) heavier, on average, than birds in either TB or TC.

Over the 1st 7 days, Groups TA, TB and TC had similar feed intakes measured as average feed intake per bird, in kg per week. There was no significant difference between the intakes of the 3 groups ($P < 0.05$).

The Groups TB and TC were put on separate feeding regimes from Day 7 onwards. The inclusion of DBP1 and DBP2 in the diet had a significant effect ($P < 0.05$) on feed intake. The 2 experimental groups (TB and TC) had lower feed intakes per bird than those in TA from Day 14 onwards. However, the difference between TB and TC was not significant ($P < 0.05$).

When the average cumulative feed intake was measured on Days 21 and 28, the birds in Groups TB and TC were found to have eaten sufficient feed to almost equalise the intake of TA. In other words, the average cumulative feed intake per bird in the 3 groups did not differ significantly ($P > 0.05$) when measured on Day 21 and again on Day 28.

The average feed intake by Day 42 is characterised by significantly higher ($P < 0.05$) intake for TA than TB or TC. TB and TC did not differ significantly ($P > 0.05$). The overall feed conversion rate of birds in Groups TB and TC were higher than in TA, but the difference was not statistically significant. This is an interesting finding because in TA a higher feed intake and a greater weight gain (Table 4) was recorded than in TB and TC.

Mortality was similar to that of commercial broiler systems, and necropsy showed that the mortalities were not feed related.

These results suggest that rations containing different levels of DBP are at least as efficient as the control treatment in converting feed into meat. The use of DBP with different salt contents in Groups TB and TC did not affect feed efficiency. Similar results were obtained by Daguro & Rivas[4] and Eruvbetine & Afolami[6], using cassava as an alternative energy feed source to maize[4,6].

Economic evaluation

Cost analysis of feed

The cost analysis of each feed according to group (TA, TB, TC) is presented in Table 5.

The cost of feed over the 1st 7 days was the same for all treatments because the birds were fed the same diet. There was also no significant difference in feed intake.

By Day 21, the cost/kg of the total cumulative feed intake for Groups TB and TC was lower than for TA due to the partial replacement of the commercial ration with DBP.

From Day 21 onwards, the birds in Group TA were given grower ration, while TB and TC received the starter ration plus DBP from Day 7 onwards.

Days 21–42 are characterised by an increase in DBP intake by Groups TB and TC, resulting in a decrease in cost/kg of the total feed consumed compared with TA, in which it remained constant.

There was little variation between Groups TB and TC in total feed consumed (Table 5). By contrast, Group TA consumed more feed than either TB or TC.

By Day 42, the price per kg, as well as the total cumulative feed intake was lower for Groups TB and TC than for TA. The total cost of feed per live bird and per kg live weight for TB and TC was lower than for TA. Feed production costs using DBP, and the starter ration from Day 7 onwards (TB, TC), were lower than those using grower ration (TA) from Day 22 onwards. This is mainly due to reduced feed consumption by Groups TB and TC.

Table 4: **Mean and standard deviation of body weight, feed intake, feed conversion rate and mortality at different ages of chickens in Groups TA** (control)**, TB and TC.**

Variable / day	TA	TB (S1 + DBP1)	TC (S2 + DBP2)
Body weight (kg)			
7	0.121 ± 0.01	0.120 ± 0.01	0.122 ± 0.02
14	0.314 ± 0.31	0.300 ± 0.04	0.294 ± 0.04
21	0.633 ± 0.08[a]	0.581 ± 0.07[b]	0.567 ± 0.07[b]
28	1.005 ± 0.01[a]	0.939 ± 0.12[b]	0.930 ± 0.12[b]
35	1.612 ± 0.19[a]	1.424 ± 0.18[b]	1.395 ± 0.19[b]
42	2.170 ± 0.21[a]	1.946 ± 0.26[b]	1.946 ± 0.24[b]
Feed intake (kg)			
7	0.119 ± 0.01	0.118 ± 0.01	0.119 ± 0.01
14	0.507 ± 0.02[a]	0.475 ± 0.01[b]	0.471 ± 0.02[b]
21	1.052 ± 0.02	1.056 ± 0.06	1.060 ± 0.05
28	1.877 ± 0.04	1.833 ± 0.09	1.887 ± 0.04
35	3.105 ± 0.08[a]	2.867 ± 0.11[b]	3.008 ± 0.05[a]
42	4.376 ± 0.11[a]	4.110 ± 0.12[b]	4.214 ± 0.05[b]
Feed conversion rate			
42	2.06 ± 0.106	2.14 ± 0.117	2.19 ± 0.06
Cumulative mortality (%)			
42	6.32 ± 4.404	5.79 ± 1.176	5.79 ± 2.201

[a,b]Means in a row for groups with no common superscript differ significantly.

Table 5: **Cost of feed during the 42-day trial for Groups TA, TB and TC. Time intervals are given to show the costs at different stages of the study.**

Day / variable	TA	TB		TC	
		S1	DBP	S2	DBP
Days 0–7					
Starter (kg)	22.65	22.42	0	22.60	0
Cost in rand per kg	1.61	1.61		1.61	
Days 0–21					
Cumulative feed intake (kg)	197.08	143.66	52.26	144.10	51.99
Cost per kg	1.61	1.61	0.00	1.61	0
Total feed intake (kg)	197.08	195.92		196.09	
Cost per kg for feed (R)	1.61	1.18		1.18	
Days 22–42					
Cumulative feed intake (kg)	598.92	366.47	181.84	371.10	195.47
Cost per kg	1.56	1.61	0	1.61	0
Total feed intake (kg)	598.92	548.31		566.57	
Cost per kg for feed (R)	1.56	1.08		1.05	
Days 0–42					
Cumulative feed intake (kg)	796.00	744.23		762.66	
Cost of feed /kg/day (R)	1.57	1.10		1.09	
Total feed cost/live bird by Day 42 (R)					
Total live weight of birds (kg)	386.14	348.22		348.32	
Total number of birds by Day 42	178.00	179.00		179.00	
Feed cost /live bird by Day 42 (R)	7.03	4.59		4.63	
Feed cost/kg live weight by Day 42	3.24	2.36		2.38	

The feed intake results in Table 5 also show that salt content had no significant effect on feed choice by the birds. The fact that there is no significant difference between TB and TC in the consumption of either starter ration or DBP, indicates that the salt content did not play a role in diet composition. Had it done so, the birds in TC would have consumed more of the S2 starter (low salt) to compensate for the high salt content of the DBP. If the birds had made a choice on the basis of higher salt contents, Group TC would have consumed more DBP than Group TB.

Total production cost, total revenue, net profit and gross margin

Total production cost (total fixed costs + total variable costs), total revenue, net profit and gross margin for Groups TA,TB and TC are shown in Tables 6, 7 and 8, respectively.

Groups TB and TC showed a reduction in the total cost of production compared to Group TA. There was also a higher profit for TB and TC than for TA, despite the fact that the total weight of birds in TA was higher than those of the other 2 groups (Table 5).

Gross margin analysis indicated that both TB and TC gave a gross margin of approximately 18 % more than TA. Feed costs (Table 5) were almost one-third less for Groups TB and TC, where DBP and choice was used, than for TA, where a conventional 2-stage ration was used.

CONCLUSION

This study confirms the central hypothesis that the use of DBP with a starter ration, as part of a free-choice feeding system, has financial advantages over a 2-stage (starter plus grower ration) feeding system in small-scale broiler enterprises. The advantage is linked to the fact that DBP is free of charge.

The use of DBP in Groups TB and TC resulted in a reduction of feed costs by nearly a third, and consequently had a positive impact on the total cost of production, net profit and gross margin per live bird and per kg of live birds in contrast to the control (Group TA). Feed inputs were reduced by approximately one-third and gross margin increased by approximately 15 %.

This study has also confirmed that chickens are able to self-select their diets when raised using CFM. This is illustrated by the performance of birds in terms of body weight, feed intake, feed conversion and the lack of feed-related mortality.

Table 6: **Total production cost, total revenue, net profit and gross margin for Group TA.**

Items	Description	Unit	Number / quantity	Prices (R) at time of trial	
				Price	Total
Fixed costs					
Broilers	DOC (male)*	Chicks	190	2.38	452.20
Total fixed costs					452.20
Variable costs					
Feed	Starter	Kg	197.08	1.61	317.30
	Grower (pellet)	Kg	598.92	1.56	934.32
Litter	Pine shavings	Bags	2.60	8.00	20.80
Vaccination	Newcastle	Bottle	0.67	8.40	5.59
	Gumboro	Bottle	0.67	17.57	11.70
Sanitation	Vet One Plus	Litre	0.11	15.47	1.75
	GL 20	Litre	0.20	17.69	3.45
Slaughtering fee	Broiler	Live bird	178.00	1.20	213.60
Total variable costs					1508.51
Total cost: fixed plus variable					**1960.71**
Total revenue					
Revenue	Slaughter weight (kg)		270.299	8.75/kg	**2365.12**
Net profit					
Revenue less costs					**404.41**
Gross margin					**856.61**

*Day-old chicks.

Table 7: **Total production cost, total revenue, net profit and gross margin for Group TB.**

Items	Description	Unit	Number / quantity	Prices (R) at time of trial	
				Price	Total
Fixed costs					
Broilers	DOC (male)*	Chicks	190	2.38	452.20
Total fixed costs					452.20
Variable costs					
Feed	Starter	Kg	510.12	1.61	821.29
	DBP	Kg	234.11	0.00	0.00
Litter	Pine shavings	Bags	2.60	8.00	20.80
Vaccination	NewCastle	Bottle	0.67	8.40	5.59
	Gumboro	Bottle	0.67	17.57	11.70
Sanitation	Vet One Plus	Litre	0.11	15.47	1.75
	GL 20	Litre	0.20	17.69	3.45
Slaughtering fee	Broiler	Live bird	179.00	1.20	214.80
Total variable costs					1079.39
Total cost: fixed plus variable					**1531.59**
Total revenue					
Revenue	Slaughter weight (kg)		243.754	8.75/kg	**2132.85**
Net profit					
Revenue less costs					**601.26**
Gross margin					**1053.00**

*Day-old chicks.

Groups TB and TC had similar body weights, feed intake, mortality and feed conversion. The feed conversion was slightly better for Groups TB and TC than for TA, although the difference was not statistically significant. This suggests that the conversion of DBP into kg live weight in Groups TB and TC was at least as efficient as in the control (TA).

The birds in this trial used free choice to provide themselves with a 'balanced' ration using the DBP and starter ration as ingredients. This is the type of choice or selection that wild animals and birds use to balance their diets and it is a natural mechanism. It is used in the context of this study to save the small-scale, resource-limited poultry producer the effort and expense of balancing rations using mathematics or computer programs. In small-scale systems (500–2000 birds) it is not economical to use pre-mixed rations in 3 stages as the broiler producer invariably ends up with partly used bags of feed. Therefore, it is likely that this would be a saving even when compared with 3-stage feeding as the difference in price between phases 2 and 3 is small (<5 %). The inclusion of DBP means that only 1 type of feed is purchased and this is supplemented with an affordable and available source of energy, *i.e.* DBP. Currently, bakeries do not charge for DBP, and Boerstra Bakery, the main supplier of bread, operates in all urban areas. In fact, these are the same areas where animal feed suppliers are

Table 8: **Total production cost, total revenue, net profit and gross margin for Group TC.**

Items	Description	Unit	Number / quantity	Prices (R) at time of trial	
				Price	Total
Fixed costs					
Broilers	DOC (male)*	Chicks	190	2.38	452.20
Total fixed costs	452.20				
Variable costs					
Feed	Starter	Kg	516.099	1.61	830.92
	DBP	Kg	247.463	0.00	0.00
Litter	Pine shavings	Bags	2.60	8.00	20.80
Vaccination	NewCastle	Bottle	0.67	8.40.	5.59
	Gumboro	Bottle	0.67	17.57	11.70
Sanitation	Vet One Plus	Litre	0.11	15.47	1.75
	GL 20	Litre	0.20	17.69	3.45
Slaughtering fee	Broiler	Live bird	179.00	1.20	214.80
Total variable costs					1089.01
Total cost: fixed plus variable					**1541.21**
Total revenue					
Revenue	Slaughter weight (kg)		243.824	8.75/kg	**2133.46**
Net profit					
Revenue less costs					**592.25**
Gross margin					**1044.45**

*Day-old chicks.

located. Therefore accessibility is the same for both products, for urban, peri-urban and rural producers as feed merchants are not located in rural and peri-urban areas.

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