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Effect of dietary inclusion of graded levels of cereal origin solid food waste on performance of Cobb 500 broilers in SNNPRS, Ethiopia

Abstract

Effect of partial replacement of maize with dried cereal origin solid food wastes (DCOSFWs) on feed intake, growth and carcass traits of Cobb500 broilers was determined in Hawassa, southern nation nationality and people regional state (SNNPRS), Ethiopia. From 3 sample kebeles, 376 households (Philadelphia=126, Gudumalle=115 and Hetteta=135) were selected through multistage random sampling technique to collect DCOSFW. One hundred sixty five Cobb500 broilers were randomly assigned to five treatment diets with three replications in a completely randomized design. Experimental diets:

Grower diets: [T0=0% DCOSFWs (control diet), T1=11.43% DCOSFWs, T2=22.86% DCOSFWs, T3=34.29% DCOSFWs and T4=45.71% DCOSFWs];

Finisher diets: [T0=0% DCOSFWs (control diet), T1=10% DCOSFWs, T2=20% DCOSFWs, T3=30% DCOSFWs and T4=40% DCOSFWs].

Data collection of the feeding trial started after an adaptation period of the chicks to the experimental pens and diets for two weeks. The DM, CP, CF, EE and ME intakes of broilers were similar ($p<0.05$) across treatment diets. However, CP, CF, EE and ME intake of finisher broilers fed on T4 were higher ($p<0.05$) than those fed on T0 (control). Body weight gain, average daily gain, slaughter weight, carcass weight, thigh, drumstick, back, thorax and total edible weights of broilers fed on T4 were higher ($p<0.05$) compared to chicks on T0. Cost of feed per kg body weight gain declined but body weight and net profit increased with increasing level of DCOSFWs. Thus, it is concluded that incorporating DCOSFWs in grower and finisher broilers diet up to 46% is economically feasible and more profitable and nutritionally adequate without adverse effect on the performance of broilers.

Keywords: broilers, cereals, finisher, food, grower, waste

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Introduction

Humanity is generating thousands tons of food wastes (FW) every day, most of which ends up as landfill. Globally about 1.3 billion tons of edible food produced for human consumption is wasted per annum, at different levels in food supply chain.[1] The use of FW as animal feed is an alternative of high interest since it produces economic, environmental and public benefits besides reducing animal production cost.[2] According to FAO (2003), the economic development of a country is normally accompanied by improvements in a country's food supply and the gradual elimination of dietary deficiencies.[3] Most Governmental programs, policies and projects are aimed at ensuring sustainable supply of foods of high biological value such as animal protein. These goals have exerted pressure on livestock industries in devising means of increasing productivity. On the other hand, human population growth, urbanization and income improvements in developing countries are progressively increasing the demand for animal origin foods. The per capita animal origin protein consumption of the sub-saharan countries is declining over time. Based on these demands, there has been a rise in the production of foods of animal origin particularly from poultry.

For increased demand of broiler production there is an increment of intensive feeding systems which is accompanied with improved breeding system that resulted in relatively greater demand for feeds with high protein and energy values.[4,5] These feeds are also used for human nutrition in East Africa including Ethiopia; consequently, they have been facing market competition with human food. The country has thus been experiencing serious shortage of conventional poultry feeds.[6] This situation highlights urgent needs to look for alternative feed resources and develop strategies on their utilization such as replacing conventional with non-conventional feedstuffs that could partly fill the gap.[7] Food waste that is generated from different sectors is one of the non-conventional type of livestock feed resources. Fast population and economic growth, expansion of higher learning institutions, governmental and private organizations are expected to yield a huge volume of food wastes that are disposed. Yet there are no studies in the country on dynamics, chemistry, economic and nutritional values of solid food wastes (SFWs) which indicates that there is a gap in effective utilization of these resources. Thus this research was conducted with the objective of determining the effect of feeding dried cereal origin solid food waste (DCOSFW) meal on feed intake, growth and carcass performances of Cobb500 broiler chicks.

Materials and methods

Description of the study area

The study was conducted in Hawassa which is the capital city of southern nations, nationalities and people's Region (SNNPR).

The city is located on the shores of Lake Hawassa in the Great Rift Valley; 275km south of Addis Ababa and 1,125km north of Nairobi, Kenya. The City lies between 60 91'-70 10'latitude North and 380 41'- 380 55'longitudes East.[8] The elevation of the city ranges from 1650 to 1700 meter above sea level (m.a.s.l). The city experiences sub humid-called 'WoinaDega' type of climate. Annual rainfall is 933.4mm. The temperature varies between 5°C in Kermit (rainy season) and 34°C in Bega (dry season).[8] Hawassa city administration has an area 157.2 sq.km which is divided in to eight sub-cities namely Hayek Dare, Menehariya, Tabore, Misrak, BahileAdarash, Addis Ketema, Hawela-Tula and Mehal sub city. Each sub city consists of a minimum of two and maximum of twelve kebeles (20 urban and 12 rural). According to Hawassa city Bureau of Finance and Economic development unpublished report of 2016, the total population of the city administration is 357,196; out of this population, 231,382 live in urban area and the remaining 125,814 live in the rural area of the administration. The city has 45,823 households (HHs) with an average of 4.22 persons per HH.

Waste and feed collection and preparation

Sampled HHs was given labeled plastic bags early in the morning at 6:00-7:00am to keep SFWs that are generated within twenty four hours. Next day, after twenty four hours on 01:00-02:00pm plastic bags were recovered, transported to collection site and weighed. Subsequently, identification and removal of non-food substances were done mechanically by hand after spreading on a plastic sheet that was laid on the ground. Finally, they were sorted into their respective categories (i.e. cereal, vegetable, root and tuber, meat and egg origins) and weighed separately. Each category of SFWs was determined by: % SFW category = (W_2/W_1) x 100; Where, W_1= total weight of SFW from a specific source. W_2=weight of individual categories of SFW. There were five treatment diets (T0, T1, T2, T3 and T4) and each treatment diet was replicated three times in a completely randomized design (CRD) with 11 chicks per replicate. During the feeding trial, samples from maize grain, soybean, noug seed cake, wheat short and dried cereal origin solid food wastes (DCOSFW) were taken from upper, middle and bottom layer of sac by using long metal pipe. Samples from the offer and refusal (grower and finisher) were collected daily by reserving 20% of it during the entire experiment period and pooled. Samples were partially dried at 60°C to constant weight and finely ground by using Willy mill to pass through 1 mm mesh size for chemical analysis.

Ration formulation of experimental diets

The trial period was classified in to grower and finisher phases; the first 21 days as grower and the last 21 days as finisher phases. The proportion of soybean in the grower and maize in the finisher diets were higher to fulfill protein and energy requirement of the birds, respectively (Table 1 & Table 2). Inclusion levels of DCOSFWs were uniform for both phases.

Table 1 Proportions of ingredients in grower broilers ration (%).

	Treatment				
Ingredients (%)	**T_0**	**T_1**	**T_2**	**T_3**	**T_4**
Maize grain	35	31	27	23	19
DCOSFW	0	4	8	12	16
Noug (Guizoita abyssinica) cake	18	18	18	18	18
Soybean	30	30	30	30	30
Wheat middling	11	11	11	11	11
Fat	2.72	2.72	2.72	2.72	2.72
Limestone	2.8	2.8	2.8	2.8	2.8
VMP	0.25	0.25	0.25	0.25	0.25
Salt	0.23	0.23	0.23	0.23	0.23

DCOSFW, dried cereal origin solid food wastes; VMP, vitamin-mineral premix T0, DCOSFW (0% of maize); T_1, DCOSFW (11.43% of maize); T_2, DCOSFW (22.86% of maize); T_3, DCOSFW (34.29% of maize); T_4,DCOSFW (45.71% of maize).

Table 2 Proportions of ingredients in finisher broilers ration (DM basis).

	Treatment				
Ingredient	**T_0**	**T_1**	**T_2**	**T_3**	**T_4**
Maize grain	40	36	32	28	24
DCOSFW	0	4	8	12	16
Noug (*Guizoita abyssinica*) cake	18	18	18	18	18
Soybean	25	24	24	24	24
Wheat middling	11	12	12	12	12
Fat	2.72	2.72	2.72	2.72	2.72
Limestone	2.8	2.8	2.8	2.8	2.8
VMP	0.25	0.25	0.25	0.25	0.25
Salt	0.23	0.23	0.23	0.23	0.23

DCOSFW, dried cereal origin solid food wastes; VMP, vitamin-mineral premix; T0,DCOSFW (0% of maize); T_1, DCOSFW (10% of maize); T_2, DCOSFW (20% of maize); T_3, DCOSFW (30% of maize); T_4, DCOSFW (40% of maize)

Experiment birds and house management

The Experimental house was equipped with electric light, heater, and foot bath. Two weeks before the arrival of the birds the wall, floor, door, windows and brooder were cleaned, washed and disinfected with savlon. The floor was covered with dry sawdust up to 5cm height. Finally, twenty four hours before the arrival of the chicks, the heater in the brooder was switched on to warm the rooms. A total of 180 day old Cob500 chicks were purchased from Alema Koudijs plc. Bishofitu, Ethiopia. They were vaccinated with marex+NCD combined vaccine for Newcastle disease on the first day, thermostable /NCD/lasota on 7th day, gumboro on 14th day for infectious bursal disease, thermostable/ NCD/lasota on 21th day and again Gumboro on 28th day. They were administered with anti-stress, vitamins and antibiotics in a solution form during the trial period. The temperature of the brooding room was controlled with thermometers. It was 35°C on the first two days of the brooding period and reduced gradually to 28°C. Light was provided for 24hours in the form of natural sunlight in the day time and artificial light in the evening. Sixty and 200 watt bulbs were used.

The chicks per replicate were fed in group and offered the pelleted chick starter diet *ad–libitum* that was purchased from Alema koudijs feed plc. After ten days of brooding period body weight was taken by using a sensitive balance and chicks transferred to the experimental house and diets. The same procedures of cleaning and disinfection done in the brooder house were employed in the experimental houses. There were five treatment diets (T0, T1, T2, T3 and T4) and each treatment diet was replicated three times in a completely randomized design (CRD) with 11 chicks per replicate which were allocated to each of the 15 pens. Birds were offered regularly with treatment diets at 7:00-7:30am in the morning and 5:30-6:00pm in the afternoon. Clean water was provided free of choice. Weight of chicks was measured weekly before delivery of daily feed and water. The experiment lasted for forty two days.

Laboratory analyses

Feed samples were partially dried at 60°C to constant weight and finely ground by using Willy mill to pass through 1 mm sieve size. Finally, samples stored in safe place for further analysis. The dry matter (DM), nitrogen (N), ether extract (EE), crude fiber (CF) and ash contents of feed ingredients, treatment diets and feed refusals were analyzed by using proximate principles.[9] Total nitrogen and crude protein in samples were estimated by using Kjeldhal method. After nitrogen content was calculated crude protein was estimated as N x 6.25. The crude fat (EE) content of sample was determined following the soxhlet procedure. Metabolizable Energy (ME) of the experimental diets was estimated as follows:

$$ME\left(\frac{kcal}{kgDM}\right) = 3951\ 54.4\ EE - 88.7\ CF - 40.8\ Ash$$ [10]

Sources and data collection methods

Experiment data collection methods

Sampled HHs were distributed with labeled plastic bags early in the morning at 6:00-7:00 am to keep SFWs that was generated within twenty four hours and recovered and transported to study site at 01:00-02:00 pm. SFWs from each source were weighed by using a sensitive balance. Subsequently, Identification and removal of non-food substances were done mechanically by hand after spreading on a plastic sheet that was laid on the ground. Finally, the proper food wastes were sorted into cereal, vegetable, root and tuber, meat and egg origins and weighed. Proportion of each category of SFWs was determined then calculated. Initial body weight (BW) of the grower birds was taken on the day of transferring from the brooder to experimental houses, subsequently on weekly basis and at the end of the trial in the mornings between 7:00 and 8:00 am before the delivery of diet and water.

Body weight gain was calculated as a difference between final and initial body weights divided by the duration of the study (42 days). Daily feed intake of individual birds was calculated as a difference between total feed offered and total refusal divided by duration of the trial (42 days) and number of birds in the group. Feed conversion efficiency (FCE) was determined by dividing average weight gain with average feed intake. At the end of the feeding trial two birds (one male and one female) per replication whose body weights were nearest to their respective group mean were selected. After overnight fasting, they were weighed (pre-slaughter weight) and killed by severing the jugular vein. Dressed carcass weight was taken after the removal of blood, feather, shank + claw, head and viscera while the skin is included. Since gizzard, liver and heart are edible in most parts of the country, were included in the carcass components too. All weights were taken using sensitive balance and expressed as percentage of the live weight. Dressing percentage was calculated as a percentage of carcass weight to slaughter weight.

Partial budget analyses

The partial budget analysis was computed to determine the profitability of incorporation of different proportions of DCOSFWs in broiler diet.[11] In this analysis chicken cost, feed and labor cost and the profit after the experiment were looked into, or differences between gains and losses for the proposed change. The net income (NI) was calculated by subtracting total variable cost (TVC) from total return. The change in net income (ΔNI) was calculated as the difference between change in total return and changes in total variable cost (ΔTVC). The marginal rate of return (MRR) measures the increase in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC) and is calculated as

$$MRR = \left(\frac{\Delta NI}{\Delta TVC}\right) x\ 100$$

Statistical Data Analysis and Model

Experimental data obtained from feed intake, daily weight gain, feed conversion ratio and carcass yields were subjected to analysis of variance (ANOVA). Significance differences among the treatment means were determined by using Duncan Multiple Range Test as contained in SAS package.[12,13] Differences between treatment groups were considered statistically significant at $p \leq 0.05$. The model used was

$$Y_i = \mu + A_i + B_j + A_i * B_j + E_{ij}$$

Where: μ, overall mean; A_i, the effect of ith treatment in the response variable; B_j, effect of sex, 1 and 2; A_i*B_j, treatment by sex interaction; and E_{ij}, error associated with the experiment.

Results and discussion

Chemical compositions of dried cereal origin solid food waste compared to some feed ingredients

The results obtained from chemical analysis of dried cereal origin solid food waste (DCOSFW) and some feedstuffs are shown in Table 3.

Higher ($p<0.05$) value of EE (23.984%), metabolizable energy (4710.90 kcal/kg) and ash (4.115%) were observed for DCOSFW. The crude fiber composition of DCOSFWs is comparable with that of maize and soybean; ash with that of soybean and wheat short; phosphorus with that of maize, soybean and wheat short. The CP content of DCOSFWs is comparable with those (12.70, 15.54 and 17.46%) earlier reported.[14,15,16] On the other hand, higher CP and ME were observed for DCOSFWs than the values of 9.02% and 3807.46kcal/kg earlier reported.[17,16] Likewise, CF was higher than that of 2.3% and 1.33%.[15,16] Similarly, EE and ME contents of DCOSFWs were higher than those (13.13%, 2.35kcal/kg) earlier reported.[17,16] This may be attributed to the contamination of COSFWs with fatty foods and oils during preparation, meal time and collection. In addition, wet COSFWs were dried under shed and consequently only fewer amounts of fat and oil were lost. Ash content of DCOSFWs was higher than those earlier reported (5.26%, 7.7% and 3.76%)[15,17,16] respectively. The higher ash content in the present study might be due to the fact that COSFWs had relatively higher sodium chloride content. Generally, differences in chemical composition between studies might be attributed to differences in food types, methods of food preparation, moisture contents, waste drying and processing methods. However, the result of present study revealed that, DCOSFWs could be considered as one of the ingredients that could partially substitute maize grain in broiler diets, due to its high CP%, EE and ME contents.

Chemical composition of treatment diets

The chemical composition of grower and finisher diets is presented in Table 4.

Table 3 Chemical composition of feed ingredients on DM basis.

	Ingredients				
Parameter	DCOSFWs	Maize grain	Soybean	Noug seed cake	Wheat short
DM (%)	92.2	89.82	92.59	88.42	91.88
CP (%DM)	11.25^{c}	7.28^{c}	38.94^{a}	22.16^{b}	14.56^{bc}
EE (%DM)	23.98^{a}	8.12^{b}	10.42^{b}	9.20^{b}	3.96^{c}
CF (%DM)	4.25^{b}	4.01^{b}	4.68^{b}	15.54^{a}	8.22^{ab}
Ash (%DM)	4.12^{ab}	2.51^{b}	3.82^{ab}	8.44^{a}	4.02^{ab}
Ca (%DM)	0.72	0.03	0.25	0.25	0.16
P (%DM)	0.81	0.79	0.71	0.31	0.67
ME (kcal/kg)	4711^{a}	3935^{ab}	3947^{ab}	2729^{c}	3273^{bc}

abc Means rows with different superscripts are significantly different (P<0.05); DM, dry mater; CP, crude protein; EE, ether extract; CF, crude fiber; Ca, calcium; P, phosphorus; ME, metabolizable energy; kcal, kilocalorie; kg , kilogram; DCOSFW, dried cereal origin solid food waste.

Table 4 Chemical compositions of grower and finisher broilers diets on DM basis.

Phase	Treatment	DM (%)	Chemical composition (%DM)						ME (kcal/kg DM)
			CP	EE	CF	Ash	Ca	P	
Grower	T0	88.38	19.53	17.29	8.67	7.40	6.35	4.93	3821
	T1	87.33	22.09	18.01	7.45	6.5	6.58	5.18	4005
	T2	86.80	23.50	19.34	10.31	8.95	7.29	4.33	3724
	T3	89.59	21.09	19.41	7.32	6.56	6	5.05	4090
	T4	90.01	18.06	19.80	6.78	6.10	5.95	5.24	4178
Finisher	T0	87.43	18.59	18.58^{b}	9.07	7.93	6.45	4.75	3834
	T1	86.13	19.13	19.69^{ab}	8.57	7.38	6.8	5.42	3961
	T2	87.75	19.31	19.68^{ab}	8.97	7.87	6.97	4.28	3905
	T3	87.80	18.81	20.24^{ab}	8.14	7.15	5.80	5.50	4039
	T4	89.50	20.75	21.02^{a}	8.90	7.96	7.12	5.32	3980

abc Means rows with different superscripts are significantly different (P<0.05); grower diets: [T0, DCOSFW (0% of maize); T1, DCOSFW (11.43% of maize); T2, DCOSFW (22.86% of maize); T3, DCOSFW (34.29% of maize); T4, DCOSFW (45.71% of maize)]; finisher diets: [T0, DCOSFW (0% of maize); T1, DCOSFW (10% of maize); T2, DCOSFW (20% of maize); T3, DCOSFW (30% of maize); T4, DCOSFW (40% of maize)]; DM, dry mater; CP, crude protein; EE, ether extract; CF, crude fiber; Ca, calcium; P, phosphorus; ME, metabolizable energy; kcal, kilocalorie and kg, kilogram

Statistically, differences (p>0.05) were not observed among the grower treatment diets. However, T1, T2 and T3 had numerically higher CP% than the control diet (T0); and, T1, T3 and T4 showed slightly higher ME than the control diet (T0). Variations (p<0.05) were observed for EE among finisher treatment diets where T4 was significantly different from T0, however, no differences (p>0.05) among T0, T1, T2 and T3. The ME and CF content of the treatment diets of present study are comparable with respective values of 4029.48kcal/kg and 3.62% earlier reported.[17] The grower and finisher diets were comparable and the variation in their CP and ME contents (19.53-23.50%; 18.59-20.75% and 3724-4178kcal/kg; 3834-4039kcal/kg, respectively) were within the acceptable range of broilers requirements. The values of CP contents of all the treatment diets were within the recommended levels suggested to be 20% for grower and 18.5% for finisher broilers.[18] These values were also higher than the minimum CP (16%) and ME (2801kcal/kg) requirements suggested for broiler breeds.[19] The CF contents of grower and finisher treatment diets range between 6.78-10.31% and 8.14-9.07%, which are above the maximum CF (6%) requirements of broiler breeds suggested.[20]

Nutrient and energy intake of broilers fed with diets containing different levels of DCOSFWs

The mean values of nutrients (g/bird/day) and ME (kcal/chick/day) intakes of grower and finisher broilers are presented in Table 5.

Nutrient intake of grower broilers increased (p<0.05) with increasing levels of inclusion of DCOSFWs. During the growing period higher (p<0.05) amount of DM, EE and ME were consumed by broilers on T4 than other groups. Least amount of DM, CP, CF and ME intakes were noted on broilers reared on the control (T0) diet. Broilers on finisher diet T4 showed highest (p<0.05) intake of DM and all the other nutrients compared with the other groups. Higher feed intake recorded in broilers fed T4 than T0 could be attributed to differences in adequacy of dietary energy which enhanced palatability of the diet and subsequently led to increased feed intake by the birds .[21] Also energy requirement of birds depends up on the amount of energy required for body maintenance which increases as body size of bird increases. Consequently, birds fed T4 needed more feed than smaller fed T0 to fulfill their maintenance energy requirement. The DM intake of the birds in the present study is in agreement with DM intake that was observed among broilers with increasing dietary inclusion level of biscuit-dough based diet up to 15 %.[22] Lower feed intake by broilers fed control diets than that containing 30% dried leftover food were reported.[23] Significantly higher daily feed intake of growing cross-bred pigs supplemented with 50% bread waste based diets was obtained.[24] Incorporating 25% bakery by products in diets of Japanese quail enhanced feed intake.[25] Increased feed intake of growing snails by 100% dietary inclusion of bread waste was achieved.[26]

Growth performance of broilers fed with respective diets containing different levels of DCOSFWs

Table 6 shows the average final body weight, daily body weight gain (g/bird/day) and FCR of broilers fed with grower and finisher diets containing different levels of DCOSFWs.

Nutrient intake of grower broilers showed differences (p<0.05) as the inclusion level of DCOSFWs increases across the treatment diets. Broilers on T4 than other groups consumed higher (p<0.05) amount of DM, EE and ME during the growing period. Reversely, least DM and ME intake were noted on broilers on the control (T0) diet. Similarly, finisher broilers on T4 showed highest (p<0.05) intake of DM and all the other nutrients compared with the other groups. On the other hand, broilers on the control diet consumed least amount of DM, CP, CF and ME than other groups. The highest live weight was from broilers fed on T4 than T0 which is the result of high feed intake and possibly also of FCR. The productivity of poultry is ultimately governed by the bird's daily feed intake because unless the bird eats to expectation, productivity will suffer.[27] On the other hand, nutrient density, availability and complementarity in the experimental diet could be accounted for the improvement in growth rate. The result of the present study agree with earlier report where broilers fed with 15% biscuit-dough based diets gained significantly higher body weight.[22] Higher body weight gain of broilers fed diet containing 20, 40 and 60% dry bakery waste was also reported.[28] Significant improvement of growth rate of layers was maintained on graded levels of indomie waste meals.[29]

However, it was stated that no significant differences were observed on live weight among broilers put on 33, 67 and 100% level of inclusion of bread waste based diets.[30] It was reported that significant differences (p>0.05) were not observed among chicks fed with varying replacement levels of biscuit for maize.[31] Earlier finding revealed that, the total weight gained by snails in different treatment groups was not significantly influenced by biscuit waste diets.[32] Earlier report also showed no significant differences (p>0.05) of body weight gain among broilers fed with varied levels of biscuit waste based diets.[31] Feed efficiency is a measure of how well a flock converts feed into weight gain or to body mass. Birds that have low feed conversion ratio (FCR) are considered inefficient feed convertors. FCR occurred among the control and experimental groups of broilers was the same (p>0.05). These similarities among the control and test diets may confirm that DCOSFW based diet is nutritionally comparable with the control diet which suggests that replacing up to 46% of maize in broiler's ration by DCOSFW is at least as efficient as the control diet without any adverse effects on the ability of birds to convert feed into meat. Comparison of FCR among different species may be of little significance unless the feeds involved are of similar quality and suitability.[33]

The result of the present study is in line with earlier reports that the FCR across treatment groups was not significantly influenced by increased level of dried bakery waste up to 60% in broilers diet.[34,28] It was indicated that different broiler groups fed on increasing level of dried bakery products showed no difference in FCR (p>0.05).[14] FCR among different broiler groups fed on biscuit-dough based diet never showed significant variation as the inclusion level was increased up to 15%.[22] Non-significant effect of bakery by-product on FCR in layer hens was reported earlier.[35] It was indicated that snails of different treatment groups fed with 0, 50, 75 and 100% levels of dietary inclusion of bread waste showed similarity on FCR among experimental groups.[26]

Carcass characteristics of broilers fed with diets containing different levels of DCOSFWs

The effects of sex and experimental diet containing different levels of DCOSFWs on carcass characteristics of broilers are presented in Table 7.

Table 5 Daily DM, nutrient (g/chick/day) and ME (kcal/chick/day) intakes of grower and finisher broilers fed with different levels of DCOSFWs.

	Treatment					
Nutrient	**T0**	**T1**	**T2**	**T3**	**T4**	**SEM**
Grower phase						
DM	84^{c}	88^{bc}	97^{ab}	95^{ab}	99^{a}	1.4
CP	17^{d}	20^{bc}	23^{a}	21^{b}	19^{cd}	0.3
CF	8^{b}	7^{c}	10^{a}	7b^{c}	7b^{c}	0.1
EE	15^{b}	17^{b}	19^{a}	19^{a}	21^{a}	0.3
ME	350^{c}	383^{bc}	386^{bc}	418^{ab}	445^{a}	6.3
Finisher phase						
DM	117^{c}	118^{c}	134^{b}	132^{b}	159^{a}	1.3
CP	23^{c}	24^{c}	27^{b}	27^{b}	35^{a}	0.3
CF	11^{c}	10^{d}	13^{b}	11^{c}	15^{a}	0.1
EE	23^{d}	25^{c}	29^{b}	29^{b}	35^{a}	0.3
ME	492^{c}	506^{c}	567^{b}	581^{b}	667^{a}	5.7

abc Means rows with different superscripts are significantly different (P<0.05); grower diets: [T0, DCOSFW (0% of maize); T1, DCOSFW (11.43% of maize); T2, DCOSFW (22.86% of maize); T3, DCOSFW (34.29% of maize); T4, DCOSFW (45.71% of maize)]; finisher diets: [T0, DCOSFW (0% of maize); T1, DCOSFW (10% of maize); T2, DCOSFW (20% of maize); T3, DCOSFW (30% of maize); T4, DCOSFW (40% of maize)]; DM, dry mater; CP, crude protein; EE, ether extract; CF, crude fiber; Ca, calcium; P, phosphorus; ME, metabolizable energy; kcal, kilocalorie and kg, kilogram

Table 6 Growth performance of broilers fed with different levels of DCOSFWs.

		Treatment					
Phase	**Parameters**	**T0**	**T1**	**T2**	**T3**	**T4**	**MSE**
Grower	Initial BW.(g)	316	307	328	319	323	3.5
	Final BW.(g)	790^{b}	826^{ab}	868^{ab}	837^{ab}	908^{a}	16.3
	DBWG (g/day)	22^{b}	24^{ab}	25^{ab}	24^{ab}	27^{a}	0.7
	Feed intake (g/chick/day)	92	95	104	102	106	2.3
	FCR (g gain/g feed)	0.24	0.25	0.24	0.24	0.25	0
Finisher	Initial BW.(g)	790^{b}	826^{ab}	868^{ab}	837^{ab}	908^{a}	1.63
	Final BW.(g)	1824^{b}	1785^{b}	2012.7^{ab}	1878^{b}	2217^{a}	54.6
	DBWG (g)	49^{b}	46^{b}	54^{ab}	49^{b}	62^{a}	1.9
	Feed intake (g/chick/day)	128^{b}	128^{b}	145^{ab}	144^{ab}	170^{a}	6.1
	FCR (g gain/g feed)	0.38	0.35	0.37	0.34	0.36	0
Overall	Feed intake (g/chick/6weeks)	4623^{b}	4694^{ab}	5231^{ab}	5175^{ab}	5809^{a}	171.5
	TBWG (g/6weeks)	1508^{b}	1478^{b}	1684^{ab}	1558^{b}	1893^{a}	52.1
	FCR (g feed/g gain)	0.32	0.3	0.32	0.3	0.33	0

abc Means rows with different superscripts are significantly different (P<0.05); grower diets: [T0, DCOSFW (0% of maize); T1, DCOSFW (11.43% of maize); T2, DCOSFW (22.86% of maize); T3, DCOSFW (34.29% of maize); T4, DCOSFW (45.71% of maize)]; finisher diets: [T0, DCOSFW (0% of maize); T1, DCOSFW (10% of maize); T2, DCOSFW (20% of maize); T3, DCOSFW (30% of maize); T4, DCOSFW (40% of maize)]; FCR, feed conversion ratio; BW, body weight; DBWG, daily body weight gained; TBWG, total body weight gained; g, gram.

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Table 7 Carcass characteristics of cobb500 broiler breed fed with different levels of DCOSFWs.

	Sex		Treatment					
Parameters	**Male**	**Female**	**T0**	**T1**	**T2**	**T3**	**T4**	**SEM**
Slaughter W.(g)	2109.0^{a}	1787.6^{b}	1863.3^{b}	1715.0^{b}	2103.3^{a}	1795.0^{b}	2265.0^{a}	54.9
carcass W.(g)	1283.0^{a}	1117.0^{b}	1178.3^{b}	1006.6^{c}	1320.0^{a}	1090.0^{bc}	1405.0^{a}	36.7
Dressing Per.	60.6	62.5	63.6	58.9	62.8	60.6	61.9	0.7
Commercial carcass parts (g).								
Neck	3	2.8	3.2^{a}	2.7^{b}	3.0^{ab}	2.7^{b}	2.8^{ab}	0.1
Skin	6.7^{a}	6.1^{b}	6.9^{a}	6.1^{ab}	5.8^{b}	6.5^{ab}	6.5^{ab}	0.1
Wing	3.5	3.3	3.5	3.4	3.3	3.4	3.4	0.1
Back	6.2^{a}	5.6^{b}	6.5^{a}	5.7^{ab}	5.9^{ab}	5.4^{b}	6.1^{a}	0.1
Brest	29.0^{a}	25.7^{b}	27.3^{ab}	25.5^{b}	29.8^{a}	25.8^{b}	28.4^{ab}	0.6
Breast	10.1	9.3	9.1	9.7	9.9	9.9	10	0.2
Drumstick	9.4	9.3	9.2^{ab}	8.7^{b}	9.3^{ab}	9.9^{a}	9.6^{a}	0.1
Thorax	3.0^{a}	2.8^{b}	3	3	2.7	3	2.7	0
Edible offal (g)								
Gizzard	1.9^{a}	1.6^{b}	1.9^{ab}	2.1^{a}	1.7^{b}	1.9^{ab}	1.3^{c}	0.1
Liver	2.2	2	2.4^{a}	2.4^{a}	2.2^{a}	2.3^{a}	1.7^{b}	0.1
TEO Wt.	4.2^{a}	3.7^{b}	4.3^{ab}	4.5^{a}	3.9^{b}	4.2^{ab}	3.0^{c}	0.1
TE Wt.	75.4^{a}	69.0^{b}	73.5^{a}	69.6^{b}	73.9^{a}	71.0^{ab}	73.6^{a}	0.8
TNEO wt.	26	25.7	24.5^{c}	27.8^{a}	24.7^{c}	26.7^{ab}	25.7^{bc}	0.3

abc Means rows with different superscripts are significantly different (P<0.05) abc Means rows with different superscripts are significantly different (P<0.05); grower diets: [T0, DCOSFW (0% of maize); T1, DCOSFW (11.43% of maize); T2, DCOSFW (22.86% of maize); T3, DCOSFW (34.29% of maize); T4, DCOSFW (45.71% of maize)]; finisher diets: [T0, DCOSFW (0% of maize); T1, DCOSFW (10% of maize); T2, DCOSFW (20% of maize); T3, DCOSFW (30% of maize); T4, DCOSFW (40% of maize)]; M, male; F, female; TEO Wt., total edible offal weight; TE Wt., total edible weight; TNEO Wt., total non-edible offal weight.

Table 8 Cost-benefit analysis of boilers production fed with different levels of DCOSFWs.

	Treatment				
Parameter	**T0**	**T1**	**T2**	**T3**	**T4**
Chick cost (birr/chick)	12	12	12	12	12
Total feed consumed (kg/chick)	4.6	4.7	5.2	5.2	5.8
Average feed cost (birr/Kg)	7	6.7	6.4	6.2	5.9
feed cost (birr/chick)	32.3	31.5	33.3	32.24	34.2
Labor cost (for drying COSFWs, birr/chick)	0	0.5	1.3	1.9	3
Transportation cost	1.5	1.9	2.1	2.5	2.9
Total variable cost (birr) TVC	33.8	33.9	36.7	36.6	40.1
Price/kg of carcass (birr/kg)	90	90	90	90	90
Average carcass weight (kg)	1.2	1	1.3	1.1	1.4
Gross income (birr/chick)	108	90	117	99	126
Total return (birr/chick)	96	78	105	87	114
Net income (birr/chick)	62.2	44.1	68.3	50.4	74
Change in total return (ΔTR)	-	-18	9	-9	18
Change in net income (ΔNI)	-	-18.1	6.1	-11.8	11.8
Change in total variable cost (ΔTVC)	-	0.1	2.9	2.8	6.3
Marginal rate of return (Δ NI/ ΔTVC)	-	-181	210	420	190

Grower diets: [T0, DCOSFW (0% of maize); T1, DCOSFW (11.43% of maize); T2, DCOSFW (22.86% of maize); T3, DCOSFW (34.29% of maize); T4, DCOSFW (45.71% of maize)]; finisher diets: [T0, DCOSFW (0% of maize); T1, DCOSFW (10% of maize); T2, DCOSFW (20% of maize); T3, DCOSFW (30% of maize); T4, DCOSFW (40% of maize)]; DCOSFW, dried cereal origin solid food wastes.

Significant differences (p<0.05) were observed on most carcass components between control (T0) and the rest of the groups fed test diets. Broilers on T4 showed higher slaughter and carcass weights, relative weights of back and drumsticks (p<0.05) than those of the rest of the treatment groups. However, this group scored least (p<0.05) relative gizzard, liver and total edible offal (TEO) weights. Higher (p<0.05) relative gizzard, liver, total edible offal (TEO) and total non-edible offal (TNEO) weights were recorded for broilers fed on T1. However, this group scored least (p<0.05) slaughter and carcass weights than those of the rest of treatment groups. Slaughter weight, relative breast, liver and total edible (TE) weights were higher (p<0.05) for broilers fed on T2. The result of carcass weight, relative skin, drumstick, TE weights were comparable (p<0.05) with those of broilers put on T3 and T4. On the other hands, comparable (p<0.05) results of relative back and breast were observed among broilers on control (T0) and T4. Dietary inclusion of different levels of DCOSFW did not reveal (p>0.05) significant effects on relative wing, thigh and thorax weights across the treatment groups. Male and female broilers showed variations (p<0.05) on different carcass characteristics. Thus, male broilers had higher (p<0.05) slaughter weight, carcass weight, relative skin, back, breast, thorax, gizzard, TEO and TE weights than those of female broilers.

However, similar values of dressing percentage, relative neck, wing, drumsticks, liver and TNEO weights were observed among male and female broilers. As the present study indicated, broilers fed on test diets are significantly higher with many carcass cuts than broilers on T0. The slaughter weight in present study is in agreement with earlier report where higher slaughter weight of broilers fed with 33% of dried cafeteria food leftover and soymeal added in pelleted concentrate ration was obtained.[16] It was reported that average slaughter weight of piglets fed on 50% of dining room and kitchen wastes showed higher slaughter weight than that of the control.[36] It was also reported high results of carcass weight of broilers with increasing level of dried cafeteria food leftover (DCFLO) and soymeal in pelleted concentrate which is in agreement with the present result.[16] The similarities on carcass yield among broilers in the current study indicate that replacing maize with DCOSFW in the treatment diets was nutritionally comparable with maize grain. Similar to the result in this study non-significant effect was reported on dressing percentage in broilers fed with biscuit waste at 25%, 50%, 75% and 100% replacement of maize in the diet.[37] Similarly it was reported non-significant differences in dressing percentage when bread waste was used in broiler diet.[38,22,30]

The pattern of gizzard and liver growth in the present study decreased while the dietary inclusion of the experimental diet (DCOSFW) increased across the treatment groups. Least gizzard weight of broilers on T4 may arise from the fine nature (texture) of the treatment diet over maize grain. Since the type of diet's particle size might have led to affect muscular functioning (grinding) of gizzard. The result of the current study is in line with previous report where significant difference in gizzard weight was obtained with 100% biscuit waste which resulted in lowest gizzard weight.[37] Significant reduction in gizzard weight with 100% bakery waste was also observed.[30] Similarly, least liver weight was obtained from broilers fed on T4 which is an indicator that treatment diet is free from anti-nutritional factors and toxic substances which could possibly be due to photogenic micro-organisms. It is a common practice to observe an increase in the size of liver and kidney as indicators of toxicity in broiler diets; and if there are toxic elements in broilers feed, abnormalities in weights of liver and kidney would be observed.[39] These abnormalities may arise from the increased metabolic rate of the organs in an attempt to reduce toxic elements or anti-nutritional factors to nontoxic metabolites.

Partial budget analysis of broilers fed with different level of DCOSFWs

Table 8 shows the profitability (cost benefit analysis) of production of broilers fed with diets containing different levels of DCOSFW.

Feed cost per kg of feed (Birr) was reduced with increasing levels of inclusion of DCOSFW in the treatment diets. Consequently, T4 had the lowest feed cost than the control diet. Similarly, highest revenue or net income was generated from sell of broilers fed on T4 than T0. The result of the cost-benefit analysis showed that feed costs decreased while the inclusion level of DCOSFW increased across treatment groups. This is an indication of economic benefit of DCOSFWs. This agree with earlier researchers who stated that poultry production may not be remunerative if costly conventional feeds cannot be replaced by cheaper unconventional feeds in the diets.[40] Feeding broilers on T4 was promising as it gave the highest net return compared to that of the control diets they had the highest body weight gain.

The diets because of present study is in line with the effects of bread waste meal observed in broiler where test diets were relatively cheaper with no adverse effect on performance.[38] Similarly the effect of replacement of maize grain by biscuit dough up to 15% revealed a reduction in production cost per unit weight gain of broilers.[22] Similar results were observed by replacement of maize with dry bakery waste in broilers and it was observed that treatment groups fed test diets were benefial.[37] The greatest economic efficiencies were obtained when in broilers diet 25% of maize grain was replaced with bakery by-products.[25] Similar trend of economics of feeding of broilers by replacing maize grain with bakery waste was reported.[41,42,30,28]

Summary and conclusion

Beneficial results were observed from broilers fed on treatment diets when up to 46% maize grain is replaced by DCOSFWs without having adverse affects on DM intake, body weight gain and carcass characteristics of the broilers. Thus this level of replacement maize with DCOSFW was profitable. It can be concluded that the results of partial budget analysis and feeding trial confirmed that replacement of maize up to 46% of maize with DCOSFW is economically feasible and nutritionally adequate and could be considered as one alternative feeding strategy which can partially substitute maize grain in urban small-scale broiler production system.

Recommendations

Concerned bodies of governmental institutions especially university cafeterias and people who are involved on urban small-scale broiler production should be trained on safe handling and segregation of food wastes from non food substances to avoid contamination. Awareness of these bodies diets should also be created about economical and nutritional benefits of DCOSFWs as ingredients of broilers diets be created. A study can also be carried out on layer hens in order to evaluate egg qualities (i.e. external and internal) and production performance by partial substitution of maize grain with DCOSFWs.

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Conflicts of interest

The author declares that there are no conflicts of interest.

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