Effect of Fish Offal Meal on Feed Intake, Growth Performances and Carcass Characteristics of Hubbard Classic Broiler Chicken Breeds

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Abstract: *The effect of partial substitution of full-fatted soybean poultry meal by fish offal meal in broiler chicks was investigated. The experiment had four treatment diets: diet-1(control, without animal protein); diet-2 (local fishmeal); diet-3 (fermented fish silage); and diet-4 (local tilapia meal). Treatment diets substituted the full-fatted soybean meal in the control diet at 5% level. Unsexed 180, one day old Hubbard Classic broiler chicks were randomly allocated tothe four treatment diets. Treatments had three replications of 15 birds per pen, in a completely randomized design. The experiment has three phases and lasted for 42 days. Overall, feed intake, body weight changes (BWC) and average daily body weight gain (ADG) were significantly ($p < 0.05$) affected by a diet that diet-1 was lower than fish offal based diets (diets 2, 3, and 4). During the starter period, birds in diet-1 and diet-4 had lower ($p<0.05$) BWC and ADG than diet 2 and 3. During the finisher period, birds in diet-4 had heavier ($p< 0.05$) BWC and ADG than diets 1 and 3. There was significantly ($p< 0.05$) better feed conversion ratio during the finisher period in diet-1 and diet-4 than the rest of the treatments. During the experimental period, higher mortality ($p<0.05$; 11.1%) was recorded in diet-1 than other diets. Diet-1 was lower in most of the carcass parameters studied. To conclude, regardless of fish species differences, incorporation of fish offal meal into plant-sourced protein diet improves the performance of broiler chicken. In addition, the results indicated that fish silage can also be an alternative to fishmeal.*

Keywords: Feed conversion ratio, feed intake, fermented fish silage, local fishmeal

1. Introduction

Chicken population in Ethiopia is estimated about 50.38 million, of which 2.56% are crossbreds and 0.54% exotic breeds (CSA, 2013). Exotic chicken breeds that are selected especially for meat purpose are termed as broilers. Nowadays it is possible to get a 2 kg live weight broiler within 35 to 42 days, with only 3 kg of feed (Klasing, 2007; Choct, 2009). Feed contributes nearly 65-70% of the total running cost in modern chicken production. In relation to this, plant-sourced protein feed is becoming expensive in Ethiopia due to factors like oilseeds export, animal feed export, competition with human food and high processing cost (Gebremedhin *et al.*, 2009; Hassen *et al.*, 2009).Therefore, utilization of unconventional feed sources like fish offal meal in animal ration would benefit poultry production (Ristić *et al.*, 2001; Agunbiade *et al.*, 2004).

Fish production in Ethiopia, in 2001, was estimated to be 15,400 tons (FAO, 2003). An estimated maximum annual fish production level from Lake Tana was estimated to be 15,000 tons. According to Ann and colleagues, about 8 tons of frozen fillets (roughly 20 tons of whole wet fish) was obtained weekly from three sources of fish suppliers from Lake Tana, with considerable seasonal variation (Ann *et al.*, 2007). In two-thirds of the year, this would amount to 680 tons of fish per annum (weight of whole wet fish).

Considering 60% of the fish weight as fish offal, 12 tons and 408 tons of fish offal (FO) can be generated on the weekly and yearly basis, respectively. Only one processing plant, throughout Amhara region, attempts to incorporate fishmeal into animal feed for sale. It collects fish offal once a week from only one of the three landing sites, excluding summer time. The remaining largest portion of the offal has been dumped around the shore contributing its share for environmental pollution. Summer rain, area of processing, processing cost and sanitation are important problems that have been encountered in fish meal processing in the region. Accordingly, alternative preparation of fish meal like Fermented fish silage can be considered to reduce pollution, storage costs, area of processing, initial capital and enables year-round production with simple technique (Windsor and Barlow, 1981; Sumarsih *et al.*, 2010). Fermented fish silage is believed to have enzymes or bioactive peptides that may enhance growth and disease resistance of animals (Enes Dapkevicius *et al.*, 2007; Garcia *et al.*, 2007).This experiment was conducted to investigate the potential use of fish offal from Lake Tana as a protein supplement in broilers diets.

2. Materials and Methods

2.1. Description of the study area

The experiment was conducted at Zenzelma campus of Bahir Dar University, which is situated 6 km north of the regional capital Bahir Dar, with an elevation of 1912 meters above sea level, between latitude and longitude of 11°37′N and 37°29′E coordinates (Google-Earth, 2013). It is found in Bahir Dar Duria District, West Gojam zone. The average daily minimum and maximum temperatures were 7 °C and 29 °C, respectively. The mean annual rainfall is 1445 mm. Cattle, Goats, Cow's milk, Chicken,and Egg are the main source of income from livestock. Lake Tana is located adjacent to Bahir Dar with an area of 3500 km^2 with a mean depth of 9 meters, and a maximum depth of 14 meters. It is the largest freshwater lake in the country and the third in Nile Basin with a leading (80%) contribution to the Blue Nile River. It contributes about 20-31% of the total fish production potential of the country (Tesfaye, 1998; Wondie, 2010).

2.2. Experimental feed preparation

2.2.1. Experimental feed processing

Fish offal from three fish species such as tilapia (*Oreochromis niloticus*), catfish (*Clarias garipienus*) and *Labeobarbus* was collected from St. George fish cooperative, around Lake Tana, in Bahir Dar city, on January 04, 2014. The fish offal was prepared into three meal types: 1) Local fishmeal - a composition of three fish species (catfish, *Labeobarbus,* and tilapia) offal; 2) Fermented fish silage - a composition of three fish species (catfish, *Labeobarbus* and tilapia) offal and 3) Local tilapia meal made of only offal of tilapia species. Red kidney bean, soybean, corn, wheat bran, limestone, salt and noug seed cake (*Guizotia abyssinica*) were purchased from Bahir Dar area. General premix, Di-Calcium Phosphate, HCL- L-lysine and D-L methionine were purchased from Addis Ababa.

Local fishmeal and local tilapia meal preparation were following the same procedure. Based on Degebassa *et al.* (2008), about 50 kg of fish offal with 15 liters of water was put in an open barrel, minced, and heated to 95-100 ^{O}C over a period of 18-20 minutes. The cooked material was pressed to separate solids (press cake) from liquids (press liquor) in which oil and water were separated by settling (FAO, 2013). The pressed by-products were spread on a rack for sun drying for five consecutive days (Degebassa *et al.*, 2008). Fermented fish silage was prepared by mincing the wet offal and boiled into a hot bowl at 115-120 ^{O}C for 5-10 minutes. Then, the boiled offal (60%) was put into a clean container with mixtures of malt (15%), molasses (5%), effective microbes (lactic acid bacteria; 5%) and sweet potato (15%) (Tibbetts *et al.*, 1981). The silo (offal and starter) was then mixed and sealed in a plastic container, airtight. It was stirred, at least twice a day for the first two weeks and preserved for one-month duration. Finally, the semi-liquid silo was exposed to the sun for five days for drying (Al-Marzooqi *et al.*, 2010).

Full-fatted soy and red kidney beans were processed in the same way, to remove trypsin inhibitors. The beans were submerged in cold water for 20 hours with occasional stirring and subsequently decanting the water and the mixture was brought to a boiling point at 100ºC for 30 minutes. The soaked beans were allowed to cool, sun-dried and ground.

2.2.2. Laboratory analysis

Representative samples of the experimental diets of local fishmeal, fermented fish silage, local tilapia meal and full-fatted soybean were sent to Bahir Dar University, the then Poly Campus, Food Science,and Technology Laboratory for chemical analysis. The samples were finely ground and sieved through 3 mm sieve with three replications each. The samples were analyzed for moisture, ash, crude protein, fat and carbohydrate (CHO) contents following the standard procedure (AOAC, 2000).

2.2.3. Feed formulation

The treatment rations were isocaloric and isonitrogenous with Metabolisable Energy for starter ranging from 3074 - 3086 and finisher 3198 - 3235 kcal kg^{-1} DM. Average crude protein for starter ranges from 22.03 - 22.45 and finisher 20.08 - 20.18%. Energy was calculated using Wiseman

(Wiseman, 1987): ME (kcal kg-1 DM) = 3951 + 54.40 fat – 88.70 crude fiber – 40.80 ash. The ration was formulated as shown in Table 1.

2.3. Management of experimental birds

The experimental house was cleaned, washed with tap water and disinfected with formic acid. The house was left empty for twenty-four hours before placing the experimental birds. A total of 180, unsexed, one-day-old Hubbard Classic broiler chicks were purchased from Andasa Poultry Farm. Four treatment groups, each with three replications, having 15 birds in each pen (replication) were distributed randomly, with a completely randomized design (CRD). The feeding trial lasted for six weeks (42 days). The total area used by the experimental birds was 9.9m^2. The birds were brooded with electric brooder of 200 Watt bulb for two weeks with 23 hours of light per day. The birds were reared on slatted floor covered with sawdust and teff straw, vaccinated against Newcastle at 1stand 7th day, and Gumboro at 14th day with Thermostable Newcastle and IBD vaccines, respectively. Birds were fed and watered *ad-libitum.* Feed leftover was collected and weighed daily for intake determination. The weight of birds was measured once every week, for seven times starting from one-day-old.

Table 1. Proportion of ingredients used in formulating broiler starter and finisher diets and chemical composition of treatment diets

	Treatment Diets							
	Starter (1-21 days) %				Finisher (22-42 days)%			
Feed components	Diet-1	Diet-2	Diet-3	Diet-4	Diet-1	Diet-2	Diet-3	Diet-4
Corn	30	32	32	32	40	44	44	44
Wheat bran	5	10	3	6	0	0	0	0
Full-fatted soybean	10	5	5	5	10	5	5	5
Full-fatted red kidney bean	24	20	25	23	24.4	22.4	19.4	20.4
Noug seed cake	26	23	25	24	22	20	23	22
Local fishmeal	0	5	0	0	0	5	0	0
Fermented fish silage	0	0	5	0	0	0	5	0
Local tilapia meal	0	0	0	5	0	0	0	5
General Premix[1]	1	1	1	1	1	1	1	1
Limestone	0.25	0.25	0.25	0.25	0.50	0.50	0.50	0.50
Di-calcium phosphate	2.00	2.00	2.00	2.00	1.50	1.50	1.50	1.50
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
L-lysine	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
DL- Methionine	0.25	0.25	0.25	0.25	0.10	0.10	0.10	0.10
Calculated composition (DM)								
Dry Matter (DM)	90.91	90.93	90.84	90.0	90.50	90.48	90.37	90.44
Ether Extract (%)	4.19	4.17	3.93	4.04	4.39	4.47	4.36	4.44
Crude Protein (%)	22.25	22.03	22.45	22.2	20.18	20.16	20.08	20.12
Methionine (%)	0.60	1.25	1.14	0.56	0.43	1.10	1.25	0.40
Lysine (%)	1.57	3.60	3.80	1.66	0.74	2.75	2.99	5.52
Meth + Cyst	0.49	0.47	0.43	0.50	0.34	0.34	0.30	0.30
Crude Fiber (%)	8.30	7.76	7.73	7.67	7.21	6.52	6.99	6.83
Ca (%)	1.11	1.09	1.10	1.10	1.08	1.07	1.07	1.07
P (%)	1.19	1.10	1.13	1.12	1.01	0.95	0.95	0.95
ME(K. cal/kg)[2]	3074	3086	3086	3085.2	3212	3235.4	3198.2	3209.1

Note: ME= Metabolizable energy, Kcal/kg; Diet-1= control diet; Diet -2= Diet containing 5% Local fishmeal; Diet -3= Diet containing 5% Fermented fish silage; Diet -4= Diet containing 5% Local tilapia meal.[1]General premix inclusion rate in the diet; Vit A, 750,000IU; D3, 450,000IU; Alpha Toco acetate¸1,000mg;Vit $_k$ 200mg;¸vit$_{B1,}$ 100mg,B2,500mg;B6,150 mg;B12, 1mg;Biotin, 5mg; Nicotinic acid,2000mg,Folic acid 50mg;Panthothenic acid,900mg;choline chloride,1000mg; Ca336400.2mg, Iron (Fe) 2000mg, Iodine(I) 120mg, Cobalt (Co) 20mg, Copper (Cu) 500mg, Manganese (Mn) 8000mg, Zinc oxide (Zn) 5000mg, Selenium (Se) 20mg, Citric acid 250 mg. [2]Metabolizable energy (ME) using Wiseman (Wiseman, 1987) formula: ME (kcal/kg) =3951 + 54.40 fat – 88.70 ash.

2.4. Data collection management

Feed intake was determined as the difference between the feed offered and refused collected every 24 hours. Individual birds were weighed weekly per pen base. The body weight change (BWC) of birds was calculated as the difference between the final and initial body weight. Average daily body weight gain (ADG) was calculated as the ratio of BWC to the number of experimental days. Feed conversion ratio (FCR) was computed as the ratio of daily feed intake to ADG. Mortality was recorded on-time and any abnormality was also monitored. At the end of the experiment, two birds per replication with body weight closer to the mean were starved overnight and weighed at slaughter for carcass evaluation using electronic weighing balance. They were killed by severing the jugular vein. Carcass evaluation was done following the procedures described by Kubena *et al.* (1974).Dressed carcass weight was measured after removing the blood and feather. Dressing percentage was calculated as the proportion of dressed carcass weight to slaughter weight multiplied by 100. Eviscerated carcass weight was determined after removing lower leg (shank), head, kidney, lung, pancreas, crop, proventriculus, small intestine, large intestine, ceca and urogenital tracts from the dressed carcass. The eviscerated percentage was determined as the proportion of the eviscerated weight to slaughter weight multiplied by 100. Fat around the proventriculus, gizzard, against the abdominal wall and the cloacae were collected and weighed. Fat percentage was calculated as the proportion of slaughter weight multiplied by 100. The edible organ parts, heart, gizzardand liver, were also weighed and expressed in percentage, in relation to slaughter weight.

2.5. Statistical analysis

The data collected from the experiment was initially fed to Excel sheet, and after checking the validity of the data it was analyzed with the General Linear Model (GLM) procedures of the Statistical Analysis System (SAS, 9.2) software. Significantly different treatment means were compared using Duncan's multiple range tests.

3. Results

3.1. Chemical composition of feed ingredients

The chemical composition of treatment feeds of fish offal meals (local fishmeal, fermented fish silage,and local tilapia meal) and full-fatted soybean meal determined are presented in Table 2. The ash and crude protein contents were higher in fish offal meals than full-fatted soybean mean. The moisture, carbohydrate and fat contents were lower in fish offal meals than full-fatted soybean. The highest moisture content was observed in the fermented fish silage (7.34%) and full-fatted soybean meal (7.4%), and the least was in the local fishmeal (4.61%).

Table 2. Chemical composition (proximate analysis) of ingredients used in the experimental diet

Sample	Moisture (%)	ASH (%)	CP (%)	FAT (%)	CHO (%)	ME (Kcal/kg)
Fermented fish silage	7.34	21.00	41.37	15.02	15.28	3.908.30
Local tilapia meal	5.79	25.59	44.26	18.52	5.85	3,778.55
Local fishmeal	4.61	27.25	48.85	16.77	2.52	3,741.70
Full-fatted soybean	7.40	4.70	36.60	18.70	32.60	4,324.15

CP = crud protein; ME= Metabolizable energy calculated using Wiseman (Wiseman, 1987) formula: ME (kcal/kg) =3951 + 54.40 fat – 88.70 ash; CHO = carbohydrate content calculated as 100-moisture-ash-CP-fat in percent

3.2. Feed intake

The feed intake (FI) of experimental birds is shown in Table 3. Birds in diet-1 (81.98 g) had significantly lower ($p<0.05$) FI than the fish offal based diets during the finisher and overall experimental period. Birds in diet-3 (119.77 g) had the highest ($p<0.05$) FI during the finisher period. Figure 1 illustrates the linearly increasing trend of overall feed intake of birds during the experimental period.

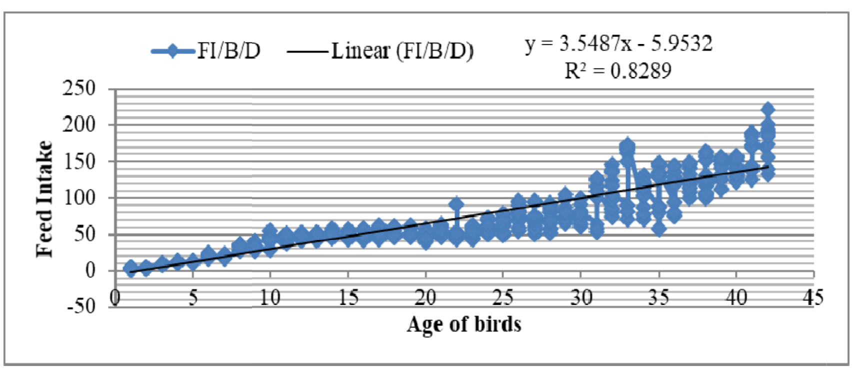

Figure 1. The trend of feed consumption bird^{-1} day^{-1} across the experimental period

3.3. Body weight change

The final body weight (FBW) and ADG are presented in Table 3. During the starter period, birds in diet-3 (417.98 g) had the heaviest (p<0.05) FBW followed by those in diet-2 (384.44 g). During the finisher period, birds in diet-1 (1208.56 g) weighed significantly lower (p<0.05) than the rest of the treatment groups. During the starter period, ADG was higher (p<0.05) in diet-3 (17.78 g), followed by birds in diet-2. During the finisher period, ADG of birds in diet-4 were significantly (p<0.05) higher followed by diet-3. For the overall period, birds in diet-1 (41.7 g) obtained the least ADG (p<0.05).

3.4. Feed conversion ratio

The feed conversion ratio (FCR) of birds during the experimental period is summarized in Table 3. During the finisher period, FCR was significantly higher (p<0.05) for diet-1 and diet-4.For the overall period, FCR was the highest for birds in diet-3 while those indiet-4 had the lowest (p<0.05) FCR among the experimental diets.

3.5. Mortality rate and problems

The mortality rate of experimental birds was significantly higher (p<0.05) in diet-1 than the fish offal based meal fed birds (Table 3). For dead birds, stretching wings and heads back, reduced feed intake, opening the mouth, increased breathing and closing the eye were observed symptoms on the verge of their death. Deformity of phalanges and leg problem was observed in heavy birds feeding on fish offal based diets.

3.6. Carcass components

The mean weight of carcass components of experimental birds is presented in Table 4. There were significant differences (p<0.05) among the treatment diets for all the carcass parameters measured, with the exceptions for the eviscerated, liver and heart (p>0.05) weight percentages. Weight at slaughter was lower for diet-1 than fish offal based diets. Birds in diet-3 had the heaviest dressing percentage (91.82 %; p<0.05) than birds in diet-1. Fishmeal based diets (diet-2 and diet-4) produced the heaviest (p<0.05) abdominal fat accumulation followed by diet-3. Diet-2 was the heaviest (p<0.05) in gizzard weight, followed by diet-4. There was no significant difference (p>0.05) in all parameters between male and female experimental birds.

Table 3. The mean feed intake, body weight change, feed conversion efficiency and mortality rate of birds fed on different diets

Parameters	Treatment diets				
	Diet-1	Diet-2	Diet-3	Diet-4	P-value
FI (g/b/d)					
Starter	31.75±2.07	36.56±2.41	39.53±2.61	34.56±2.21	0.118
Finisher	81.98±3.93^{c}	114.62±5.54^{ab}	119.77±4.94^{a}	103.99±5.08^{b}	0.001
Entire experiment	56.86±3.15^{b}	75.59±4.61^{a}	79.65±4.54^{a}	69.27±4.15^{a}	0.001
IBW (g/b)	44.52±0.05	44.73±0.06	44.8±0. 058	44.72±0.034	0.708
FBW (g)					
Starter	332.89±6.16^{c}	384.44±6.59^{b}	418.22±6. 74^{a}	335.13±8.73^{c}	0.0001
Finisher	1208.56±7.77^{b}	1499.81±24.43^{a}	1518.75±18.79^{a}	1492.27±19.81^{a}	0.0001
BWC (g/b)					
Starter	288.37±6.16^{c}	339.71±6.59^{b}	373.41±6.74^{a}	290.41±8.73^{c}	0.0001
Finisher	875.67±9.56^{c}	1115.37±23.92^{ab}	1100.53±18.11^{b}	1157.14±20.84^{a}	0.0001
Entire experiment	1164.04±7.77^{b}	1455.08±24.43^{a}	1473.95±18.79^{a}	1447.55±19.81^{a}	0.0001
ADG (g/b)					
Starter	13.73±0.29^{c}	16.18±0.32^{b}	17.78±0.32^{a}	13.83±0.42^{c}	0.0001
Finisher	41.7±0.46^{c}	53.11±0.14^{ab}	52.41±0.86^{b}	55.1±0.99^{a}	0.0001
Entire experiment	27.72±0.19^{b}	34.64±0.58^{a}	35.09±0.45^{a}	34.47±0.47^{a}	0.0001
FCR (Feed: Gain)					
Starter	2.33±0.15	2.26±0.06	2.22±0.01	2.51±0.13	0.287
Finisher	1.97±0.07^{b}	2.16±0.06^{a}	2.29±0.02^{a}	1.89±0.05^{b}	0.002
Entire experiment	2.05±0.04^{bc}	2.19±0.06^{ab}	2.27±0.02^{a}	2.01±0.04^{c}	0.008
Mortality rate	11.11±2.22^{a}	2.22±2.22^{b}	0^{b}	4.44±2.22^{b}	0.017

Diet-1= control diet; Diet -2= Diet containing 5% Local fishmeal; Diet -3= Diet containing 5% Fermented fish silage; Diet -4= Diet containing 5% Local tilapia meal. Means within a row with different superscripts differ significantly (P < 0.05); SEM: Standard error of the mean; ADG: Average Daily body weight Gain; BW: Body weight; IBW: Initial BW; FBW: Final BW; BWC: body weight change; FCR: Feed conversion ratio; FI: Feed intake.

Table 4. Carcass components and organ weights of broilers fed different fish offal based protein diets

Parameters	Treatment diets				sex	
	Diet-1	Diet-2	Diet-3	Diet-4	Male	Female
Slaughter wt.(g)	1024.1±9.79[b]	1383.72±1.62[a]	1390.7±14.52[a]	1377.5±9.34[a]	3020.8±49.16	1267.3±45.92
Dressing %	84.23±0.53[b]	85.8.8±0.8[ab]	88.49±1.69[a]	85.84±0.24[ab]	86.61±0.87	85.50±0.71
Eviscerated %	67.97±0.87	68.20±0.55	69.67±0.85	69.27±0.90	68.99±0.55	68.57±0.61
Abdominal Fat%	0.76±0.03[c]	0.98±0.02[a]	0.91±0.03[b]	1.01±0.03[a]	0.93±0.03	0.9±0.03
Liver wt (g)						
Liver %	2.29±0.11	2.18±0.07	2.11±0.09	2.25±0.06	2.20±0.05	2.22±0.06
Heart %	0.57±0.02	0.53±0.01	0.54±0.02	0.55±0.01	0.55±0.01	0.54±0.01
Gizzard %	1.63±0.07[c]	2.17±0.05[a]	1.53±0.05[c]	1.98±0.07[b]	1.87±0.08	1.78±0.09

Diet-1= control diet; Diet -2= Diet containing 5% Local fishmeal; Diet -3= Diet containing 5% Fermented fish silage; Diet -4= Diet containing 5% Local tilapia meal. Means in the same row with different subscripts are significantly different ($P < 0.05$).

4. Discussion

4.1. Chemical composition of feed ingredients

The higher ash content of fish offal meals than plant protein agrees with literature (Ojewola *et al.*, 2005) that mineral-rich parts in fish offal, as bone, cartilage and scales increased the ash content. The relatively lower crude protein content in fermented fish silage might be due to the lower amount (only 60%) of fish offal input than the other fishmeal diets and the processing methods. Generally, the proximate analysis of this study is in line with previous reports on fish species of crude protein, ether extract and ash contents (Kassahun *et al.*, 2012). But, the ash and fat components of the local fishmeal in this study was higher and protein content was lower than the study by Ojewola *et al.* (2005).This could be due to the difference in selecting the fish offal parts for local fishmeal processing and the method of reducing the fish oil during processing.

4.2. Feed intake

The reduction in feed intake observed in diet-1 might be due to the remnants of anti-nutritional factors (ANFs) after treatment and relatively higher crude fiber in the beans. High fiber from processing is considered as feed intake limiting factor (Obasuyi and Nwokoro, 2006; Rougière and Carré, 2010). The reason for lower FI of diet-4 during the finisher period was probably due to tilapia's higher fat content known to have low digestibility by starter birds. One of the major problems associated with the use of fats in poultry nutrition is the inefficient digestion and absorption in young chickens (Al-Marzooqi and Leeson, 1999). The leading feed intake of diet-3 could be due to, relatively, higher palatability than other diets. Previously, Enes Dapkevicius *et al.* (2007)reported that lactic acid fermentation improves the acceptability of animal feeds.

4.3. Body weight change

The poor growth performance in diet-1 than fish offal based diets could be feed quality difference, which is from the anti-nutrition factors and the reduced non-protein nitrogen content of soybean meal during processing (Ofongo and Ologhobo, 2007; Al-Marzooqi *et al.*, 2009). This finding generally agrees with other observations that an inclusion of animal protein in broiler ration increases performance than plant-sourced protein diets alone (Olomu, 1976; Ojewola *et al.*, 2005). The reason for the highest ADG during the starter period in diet-3 could be due to the fermented fatty acids and amino acids in fish offal became readily absorbable by young birds. Lactic acid fermentation provides fat stability in fish silage and improving acceptability in the animal feed (Enes Dapkevicius *et al.*, 2007). Based on Al-Marzooqi *et al.* (2010), fermented fish silage is recommended to have some soluble proteins rapidly absorbed and promote an early protein synthesis in chickens. But, during the finisher period, diet-4 was significantly better ($p<0.05$) in gain than diet-1 and diet-3. The reason could be the physiological adaptation of grower birds in utilizing crude fat in fishmeal diets. Fishmeal is fairly rich in all amino acids including unidentified growth factors and can rectify amino acid deficiency (Ojewola *et al.*, 2005). This finding was in line with literature that none of the animal protein sources were inferior to the plant-based protein (control) (Mikulec *et al.*, 2004; Ojewola and Annah, 2006). Whereas, other scholars reported that the inclusion of fish silage in diets for broiler chicks improved growth similar with soybean meal or fishmeal (McNaughton *et al.*, 1978; Johnson *et al.*, 1985).

4.4. Feed conversion ration (FCR)

The poor efficiency of diet-3 among the rest of the diets could be relative; it's better palatability and lowers CP content than the fish meal (diets 2 and 4). Besides, higher ash content among fish offal based diets than diet-1 could be the reason for reducing their feed conversion efficiency. The lower efficiency of the experimental birds than the standard of the same Hubbard classic birds could be the feed quality, housing condition, water intake, temperature stress, cell stress and general management of birds (Moges *et al.*, 2011).

4.5. Carcass components

The results obtained showed that higher live weights led to higher dressed weights which agree with other findings (Tesfaye *et al.*, 2012). Lighter birds in diet-1 relatively with the larger surface area were covered with feather as much as the heavier birds do. The carcass weight in Hubbard classic birds in this study was similar to other reports (Gangwar *et al.*, 2010; Girma *et al.*, 2011; Tesfaye *et al.*, 2012). The lower abdominal fat accumulation in diet-3 (0.91) than fishmeal-based diets (diet- 4 (1.01) and diet-2 (0.98)) could be an indication of the efficiency of diet-3 in producing quality lean meat since most carbohydrate (CHO) was replenished during fermentation of fish silage. The lowest fat accumulation in diet-1 birds could be due to feed intake deprivation. Based on Kubena *et al.* (1974) environmental temperature results in higher percentage of abdominal fat The weather fluctuation in the study area might have a contribution to lowering the overall abdominal fat of the experimental birds. The weight of gizzard in fish offal based meals (ranged 1.98- 2.17) was similar to the findings of Ojewola *et al.* (2005) that the fishmeal and crab meal diets ranged between 2.04 – 2.49%.Similar gizzard weights in diet-1 and diet-3 and also diet-2 and diet-4 might be due to the texture of the meals that the former were finer and the later coarser, respectively. An increase in muscular activity in the gizzard occurs breaking down more coarse meal in diets compared to the finer meal (Etuk *et al.*, 2012).

4.6. Mortality rate

The highest mortality rate in diet-1 could probably be due to the disease occurrence during the second week of the trial and the presence of ANFs and toxic effects from plant source ingredients in the diet. A similarcase was previously observed when birds fed on treated beans (Gangwar *et al.*, 2010). The minor incidence of lameness, like improper growth of phalanges and deformed legs observed in fish offal based meals, could be relatively due to their heavy, faster weight gain that limited movement.

5. Conclusion

Finally, from the above results, it can be concluded that fish species difference had no negative effect on the overall performance of the experimental birds except local tilapia meal which was relatively less effective for starter birds implying the potential use of fish-offal for poultry feed. The substitution of full-fatted soybean meal by fish offal meal (at 5%) had no negative effect on the performance of broilers, rather improved plant-sourced protein diet when mixed. Besides, fermented fish silage can be an alternate meal of fishmeal (in diet-2 and diet-4) at 5% inclusion rate for the positive effects of intake and production suitability than fishmeal diets.

Conflict of interest

The authors declare that there is no conflict of interest to publish this manuscript in the journal.

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