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The Effect of Different Levels of Full Fat Sunflower Seed on Performance of Broiler Chickens

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Abstract: A study was conducted to evaluate the nutritive value and inclusion level of Sunflower Seed (SFS) in broiler diets. SFS contained 38.7% Ether Extract (EE), 16.9% CP, 14.9% Crude Fiber (CF), 3.5% ash, 0.57% lysine and 0.46% methionine (89.2% DM basis). The AME (kcal kg^{-1}) content of SFS in roosters was 5,225 and in broilers at 4, 18 and 35 days of age was 3493, 5132 and 5162, respectively. The CP, EE and CF digestibilities were 80.4, 71.2 and 11.4%, respectively. In an isocaloric and isonitrogenous diet containing SFS at 0, 5, 10, 15 and 20%, SFS up to 20% did not affect weight gain and feed consumption but the feed conversion ratio was improved ($p<0.05$) when broilers were fed 15 or 20% SFS in the starter and finisher diets. CF digestibility of starter diet was significantly lower when 15 or 20% SFS was included. CF digestibility of the finisher diet and digestibility of other nutrients in starter and finisher diets were comparable in all treatment groups. Liver and muscle lipid content, plasma total and high-density lipoprotein cholesterol content, muscle cholesterol content, dressing percentage, liver weight and giblet weight (as % live weight) were comparable among all treatment groups. Abdominal fat was increased in birds fed 20% SFS. Percentage skin was decreased in broilers fed = 10% SFS.

Key words: Digestibility, metabolizable energy, sunflower seed, brailer chickens, amino acid, Iran

INTRODUCTION

Trends toward formulating high-energy diets for broiler chickens make it necessary for inclusion of fats and oils up to 10% in broiler feeds. Fats and oils are rich sources of energy, containing 9.4 kcal g^{-1} gross energy (4.15 kcal g^{-1} in carbohydrate) but are more costly on a weight basis and may contain impurities (Blair and Potter, 1988). As an alternative to fats and oils, full-fat oilseeds (Ajuyah *et al*., 1993; Ortiz *et al*., 1998) such as soybean seed are used to replace the supplemented fats and oils in broiler diets. However, soybean seed has antinutritional factors such as trypsin inhibitors which need further processing, thus increasing the cost of soybean seed. Among the various oil seeds available on the market, Sunflower Seed (SFS) contains more Ether Extract (EE) (38-40%) and is available at a relatively lower price. This high EE content contributes to a high ME per unit or high energy density of feed. The increased production and availability of hybrid SFS coupled with its oil content makes SFS a potentially desirable ingredient in poultry feeds. SFS has been used previously in poultry diets (Ortiz *et al*., 1998; Arija *et al*., 2000). SFS has been recommended in broiler diets up to 20% (Daghir *et al*., 1980), 22.5% (Eluzubeir and Ibrahim, 1991) and 50% (Cheva-Israkul and Tangtaweewipat, 1991). All of those studies were conducted with respect to the final BW gain but other important parameters such as mineral balance studies, Crude Fiber (CF) and EE digestibility were not elaborated in those studies. Although, studies have been done with full-fat SFS in poultry diets very little research has been conducted to study the SFS proximate composition, amino acid content and fiber digestibility. Sunflower meal (deoiled seeds) has been extensively studied in poultry diets as a protein source. One of the major limiting factors in sunflower meal incorporation is its fiber content. Earlier reports revealed poor digestibility of SFS meal due to its higher lignification (Villamide and Sanjuan, 1998). However, it is not known whether the SFS fiber digestibility would improve when fed as full-fat seed. Although, fibrous ingredients have been involved in a limited number of studies as diluents for restricting feed intake, their effect in high energy diets for broilers has not been studied. Full-fat SFS would increase fat and the fiber contents of the diet. Reports of ME content of full-fat SFS differ widely based on the EE content of the SFS (Daghir *et al*., 1980; Eluzubeir and Ibrahim, 1991). ME content of SFS in the earlier reports was determined in adult birds. Full-fat SFS with its high-fat content might have lower ME content in the chicks as fats and oils are poorly absorbed by youngchicks (Renner and Hill, 1961). Hence, in this trial, full-fat SFSMEcontent was determined in roosters and broiler birds at different ages. Sunflower oil is rich in unsaturated fatty acids. Unsaturated fatty acids have been reported to reduce the fat and cholesterol contents of broiler birds (Newman *et al*., 2002). It would be of interest to know whether full-fat SFS could elicit such an effect in broilers. Reduction of fat and cholesterol content has higher consumer acceptance. In view of the lack of information on the value of full-fat raw SFS for poultry, the study reported here was initiated to confirm its nutritional worth and to establish its optimal level of inclusion in highdensity diets for broilers in terms of production performance and carcass quality.

MATERIALS AND METHODS

Proximate analysis: Samples of SFS were collected from different sources and the proximate compositions and calcium and phosphorus contents (Table 1) were determined (AOAC, 1990). Lysine content was determined by forming an ε-dinitropyridyl derivative of lysine and methionine was determined by reaction with nitroprusside solution (Sadasivam and Manickam, 1992). CF was fractionated into neutral detergent fraction, acid detergent fraction, cellulose, hemicellulose and lignin (Goering and van Soest, 1970). A sample that had 38.7% oil, 16.9% CP, 14.9% CF, 3.5% ash, 0.57% lysine and 0.46% methionine (89.2% Dm basis) was selected and used in the following experiments.

AME: The AME of SFS that was used in subsequent biological experiments was estimated (Farrell, 1978) using 5 roosters. Five roosters (21 week of age) of approximately the same BW were housed in metabolic cages, starved for 24 h and then force-fed with 50 g of ground SFS. The fecal excreta for the 24 h period were collected (individually from each bird), thoroughly homogenized, weighed and dried in an oven at 80°C for 24 h and then the DM was calculated. The Gross Energy (GE) contents of the ground SFS and excreta were analyzed in an adiabatic bomb calorimeter adapting standard procedures. AME was calculated as follows:

$$\frac{(\text{GEfeed x DMfeed})\text{-}(\text{GEexcreta x DMexcreta})}{\text{DMfeed}}$$

The AME content of SFS for broiler birds in different age groups was calculated as earlier using 8 broiler chicks except that the birds were force-fed with 10, 25 and 50 g of ground SFS, respectively at 4, 18 and 35 days of age.

Digestibility of SFS: The digestibility of SFS nutrients was quantified with 5 adult roosters by using chromic oxide at 5 g kg^{-1} as a digestibility marker. The birds were housed individually in metabolic cages and fed ground SFS *ad libitum* for 48 h. The total feed consumed and the excreta were measured individually. The proximate components in feed and excreta were quantified and the digestibility of nutrients was calculated on a percentage of DM basis and expressed as percentage of nutrients absorbed.

Table 1: Analyzed nutrient composition (%), ME (kcal kg^{-1}) content and digestibility of sunflower seeds (on DM basis)

Items	Values
Nutrients	
CP	17.00
Crude fiber	14.90
Ether extract	38.40
Ash	3.40
Nitrogen free extract	25.90
Calcium	0.34
Phosphorus	0.22
Lysine	0.55
Metionine	0.45
Neutral detergent fraction	29.70
Acid detergent fraction	21.00
Hemicellulose	8.90
Cellulose	14.10
Lignin	
AME	
Rooster	5,225.00
Broiler, 4 days old	3,493.00
Broiler, 18 days old	5,132.00
Broiler, 35 days old	5,162.00
Digestibility	
DM	65.70
CP	80.40
Ether extract	71.20
Crud fiber	11.40

Feeding trial: Five experimental isocaloric and isonitrogenous broiler starter and finisher diets were formulated to contain 0, 5, 10, 15 or 20% SFS (Table 2). Broiler starter diet (2,930 kcal kg^{-1} ME; 23% CP) was fed from 0-3 week. Broiler finisher diet (3,200 kcal kg^{-1} ME; 20% CP) was fed from 4-6 week. One hundred eighty 1 day old commercial broiler chicks (cobb strain) were weighed, wing-banded and distributed randomly to 5 treatments with 3 replicates (12 chicks in each replicate/pen) in each treatment. The chicks were reared in deep litter on peanut hulls in 1×1.5 m pens. Water and feed were provided *ad libitum*. Body weight and feed consumption were determined at the end of the 3rd and 6th weeks on a per-pen basis. Mortality was recorded when it occurred. Feed conversion was calculated as the ratio of the feed consumed to the total BW of live birds in that pen. Digestion trials for broiler starter and finisher diets were conducted at the 3rd and 6th week, respectively using broiler birds of the same hatch. Three chicks per treatment were housed individually in metabolic cages and digestibility trials (chromium oxide as marker) were conducted. The experimental ration and water were

Table 2: Ingredient and nutrient compositions of experimental diets

	Level of SFS included (0-3 weeks) (%)					Level of SFS included (3-6 weeks) (%)				
Items	0	5	10	15	20	0	5	10	15	20
Ingredients										
Corn	55.8	46.6	37.4	28.2	19.0	55.0	54.0	52.8	47.5	38.1
SBM[1]	39.9	37.8	35.7	33.7	31.9	35.5	33.9	32.2	30.3	28.5
DORB[1]	0.0	6.4	12.7	19.0	24.8	0.0	0.0	0.0	3.5	9.7
SFS[1]	0.0	5.0	10.0	15.0	20.0	0.0	5.0	10.0	15.0	20.0
Ricebran oil	0.0	0.0	0.0	0.0	0.0	5.5	3.2	1.1	0.0	0.0
Calcite	0.8	0.8	0.8	0.8	0.9	1.3	1.3	1.3	1.3	1.4
DCP[1]	2.2	2.1	2.1	2.0	2.1	1.6	1.5	1.4	1.2	1.1
Metionine	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.2	0.2	0.2
Vitamin-mineral mix[2]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Analyzed nutrients (%)										
Dry matter	90.0	90.5	90.9	91.0	90.6	91.0	90.6	90.6	90.7	91.1
Crud protein	22.9	22.9	23.1	23.1	23.0	20.1	20.1	20.1	20.1	20.0
Crud fiber	3.0	4.1	5.9	8.1	10.3	3.1	3.0	2.9	3.2	4.1
Ether extract	1.5	3.2	4.8	6.5	8.3	6.1	7.0	5.7	7.9	10.0
Total ash	8.9	8.6	8.6	8.7	8.8	8.5	8.7	8.0	8.7	8.7
Calculated values (%)										
NFE[1]	53.7	51.7	48.5	44.6	40.2	53.2	51.8	53.9	50.8	48.3
Calcium[3]	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
Phosphorus[3]	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9
Methionine[3]	0.6	0.6	0.6	0.6	0.6	0.4	0.4	0.4	0.4	0.4
Lysine[3]	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
Methionine + cystine[3]	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.7	0.7	0.7
ME (kcal kg)$^{-3}$	2,930	2,930	2,930	2,930	2,930	3,200	3,200	3,200	3,200	3,200

[1]SBM = Soybean Meal; DORB = Deoiled Rice Bran; SFS = Sunflower Seed; DCP = Dicalcium Phosphate; NFE = Nitrogen-free Extract. [2]Supplied per kilogram of feed: vitamin A, 8,250 IU; vitamin D3, 1,200 IU; vitamin E, 10 mg; vitamin K, 1 mg; riboflavin, 5 mg; thiamine, 1 mg; pyridoxine, 2 mg; cyanocobalamine, 15 µg; niacin, 15 mg; calcium D-pantothenate, 10 mg; folic acid, 1 mg; Mn, 54 mg; Zn, 54 mg; Fe, 2 mg; I2, 0.2 mg; Cu, 0.2 mg; Co, 0.1 mg, [3]Calculated using NRC (1994) values

provided *ad libitum*. The quantity of feed consumed and excreta voided were recorded for 48 h. Excreta collected (2 times, once in 24 h) during the 48 h period and the starter and finisher diets were analyzed for their proximate principles, calcium, phosphorus, total ash and gross energy. The AME of rations and the digestibility of different nutrients were calculated and expressed as percentages.

Sample collection: At 6 weeks of age, 9 birds per treatment (3 per pen) were selected randomly and blood was collected by heart puncture. Plasma was separated and analyzed for total cholesterol and High Density Lipoprotein (HDL) cholesterol colorimetrically using kits. About 2 briefly, cholesterol was oxidized to enone and hydrogen peroxide which were further converted into a colored dye and measured colorimetrically. The HDL cholesterol was measured in thesupernatant after precipitating the very low-density lipoproteins and low-density lipoprotein fraction using dextran sulfate (Wybenga *et al*., 1970). The birds were slaughtered and their carcasses were scalded in 80°C water for 3 min and then defeathered. The head was cut off at the second cervical junction, feet were cut off at the ankle joint (tibiotarsus-tarsometatarsus), the carcass was eviscerated and the weight was recorded as dressed weight. Dressing percentage was expressed as the percentage of dressed BW to live BW. Giblet weight (heart, gizzard and liver), skin weight and abdominal fat pad weight were recorded as percentages of live BW. About 2 g of liver and muscle (2 g each of pectoral major and gastrocnemius, pooled) were collected and thoroughly homogenized and lipid was extracted (Folch *et al*., 1957). The total cholesterol in the extracted lipid of the muscle was solubilized in chicken serum 2 and estimated as described earlier.

Statistics: Comparison of data was made using one-way ANOVA as per Snedecor and Cochan (1989). Data in percentages were subjected to arc sine transformation. If F-values were significant, critical differences were calculated to separate significant treatment means. Duncan (1955) multiple range F-test values were used to compare differences among treatment means ($p<0.05$).

RESULTS AND DISCUSSION

Composition: The mean proximate composition, calcium, phosphorus, lysine, methionine and AME content of SFS and the digestibility of SFS nutrients are shown in Table 1. The AME content (kcal kg^{-1}) of SFS used in this experiment was 5,225 in the case of roosters and 3,493, 5,132 and 5,162 for broilers at 4, 18 and 35 days of age.

Broiler production performance: Weight gain and feed consumption (Table 3) were not affected by the SFS level

Table 3: Effect of Sunflower Seed (SFS) inclusion on production performance

	Body weight gain (week) (g)			Feed consumption (week) (g)			Feed conversion ratio (week)		
SFS inclusion (%)	0-3	3-6	0-6	0-3	3-6	0-6	0-3	3-6	0-6
0	556	1,037	1,593	807	2,220	3,027	1.45[d]	2.14[b]	1.90[c]
5	553	1,055	1,608	797	2,226	3,023	1.44[cd]	2.11[b]	1.88[c]
10	559	1,054	1,613	795	2,201	2,996	1.42[bc]	2.09[ab]	1.86[bc]
15	565	1,088	1,652	791	2,208	2,999	1.41[b]	2.03[a]	1.81[ab]
20	581	1,062	1,643	800	2,154	2,954	1.38[a]	2.03[a]	1.79[a]
SEM	23	19	32	7	42	47	0.01	0.02	0.02

[a-d]Means within a column with no common superscript differ significantly ($p<0.05$)

Table 4: Effect of Sunflower Seed (SFS) inclusion on slaughter traits1

SFS inclusion (%)	Dressing percentage (%)	Liver (%)	Giblet (%)	Abdominal fat (%)	Skin (%)
0	72.0	2.2	5.1	1.5[a]	4.8[c]
5	72.7	2.2	5.1	1.7[ab]	4.7[bc]
10	72.2	2.2	5.1	1.7[ab]	4.6[ab]
15	73.0	2.2	5.1	1.7[ab]	4.5[a]
20	73.0	2.3	5.2	1.8[b]	4.6[ab]

[a-c]Means within a column with no common superscript differ significantly ($p<0.05$)

Table 5: Effect of Sunflower Seed (SFS) inclusion on the digestibility of broiler starter and finisher diets (%)

SFS inclusion (%)	Dry matter digestibility	Nitrogen retention	Ether extract digestibility	Crude fiber digestibility	Calcium retention	Phosphorus retention	ME (kcal kg^{-1})
Starter diet							
0	70.5	77.9	80.1	37.2[c]	68.7	68.4	2.958
5	70.8	78.2	80.3	35.3[bc]	68.0	68.0	2.967
10	71.1	78.1	80.5	33.2[abc]	67.9	67.9	2.931
15	70.0	78.2	80.2	32.9[ab]	68.0	67.8	2.942
20	69.0	78.1	82.5	30.7[a]	68.2	67.6	2.999
SEM	0.7	0.5	0.6	0.7	0.8	0.9	22.000
Finisher diet							
0	70.9	79.2	80.3	36.4	54.4	53.9	3.210
5	70.5	79.2	80.3	37.3	54.2	54.1	3.217
10	70.9	79.4	80.5	37.6	54.5	54.1	3.209
15	70.8	79.3	80.6	37.1	54.4	55.0	3.226
20	70.8	79.4	80.3	36.4	54.4	54.3	3.293
SEM	0.9	1.0	1.1	1.0	0.8	0.7	33.000

[a-c]Means within a row with no common superscript differ significantly ($p<0.05$)

of inclusion. Better feed conversion ratio was recorded in groups fed 15 or 20% SFS in both broiler starter (2.8 and 4.8%) and finisher (5.1 and 5.1%) diets than in the control group. The mortality rate was not influenced by the SFS inclusion.

Liver, giblet and abdominal fat weight: The liver and giblet percentage weight (as percentage of live BW) and the dressing percentage (Table 4) did not differ among treatments. The abdominal fat was increased in those fed 20% SFS. Percentage skin was decreased in broilers fed ≥10% SFS.

Muscle and serum lipids, total and HDL cholesterol content: The muscle lipid, serum lipid and total and HDL cholesterol contents were not significantly affected by thelevel of SFS inclusion. The liver lipid was 9.4-9.5%, muscle lipid was 2.7-2.9%, plasma total cholesterol was 190-210 mg dL^{-1} muscle total cholesterol was 96-107% mg and plasma HDL cholesterol was 42-50 mg dL^{-1}.

Digestibility of starter and finisher diets: The CF digestibility was lower in the starter diets containing 15 and 20% SFS, whereas the finisher diets showed no difference in CF digestibility. Nitrogen, DM, EE, calcium retention and phosphorus retention did not differ among treatments in the starter and finisher diets (Table 5).

The proximate composition of SFS revealed a high content of EE (38.5%) and a moderate amount of CP (17%). Earlier reports of Cheva-Israkul and Tangtaweewipat (1991) and Eluzubeir and Ibrahim (1991) have indicated similar composition. The calcium (0.34%) and phosphorus contents (0.22%) of the SFS studied were lower than the reported values of Uwayjan *et al.* (1983). The methionine (as percentage of CP) content (2.71%) was higher than the reported values of Uwayjan *et al.* (1983), Kashani and Carlson (1988) and Cheva-Israkul and Tangtaweewipat (1991). Harris *et al.* (1978) have discussed the factors that may cause variation in the composition of SFS. The AME content (5,225 kcal kg^{-1}) of SFS in roosters was higher than that in earlier reports (Kashani and Carlson, 1988; Cheva-Israkul and

Tangtaweewipat, 1991). Differences in nutritive factors such as EE and amino acidcontent among different strains of SFS plants (Harris *et al*., 1978) are responsible for these observed differences. The SFS AME in chicks at 4 days of age was lower than the AME in those at 18 and 35 days of age. Newly hatched chicks have reduced fat absorption (Carew *et al*., 1972). The hemicellulosic compounds are not digested by young birds, whereas adult birds are able to digest substantial amounts of hemicellulose (Janssen and Carre, 1989). With the SFS fat and hemicellulosic content being high, a decreased AME at 4 days can be expected. The better feed conversion ratio observed in the 15 and 20% SFS was due to the increase in the AME content of the broiler finisher diet (Table 5). Although, the diets were isocaloric, based on the AMEcontent of SFS as determined in adult roosters, biological evaluation of the AME content of broiler diets indicated numerically higher AME content of 20% SFS groups. The higher AME in 20% group could be due to the associative effect of basal diet components (Sibbald and Kramer, 1978) and increased apparent fat availability with as level of fat increasaed up to 12% (Sell and Hodgson, 1962). Although, the feed conversion ratio was improved significantly, BW did not differ among the treatments. The digestibility of SFS CF was very poor (11%) in adult roosters (Table 1). Earlier research of Villamide and Sanjuan (1998) indicates that sunflower meal has poor fiber digestibility because of its higher degree of lignification. Although, the SFS CF digestibility was very poor, the CF digestibility of the compounded diets with up to 10% SFS in the starter diet and up to 20% SFS in the finisher diet was not affected (Table 5). Digestibility was 18% higher in the finisher diet than in the starter diet when 20% SFS was included, whereas the CF digestibility was the same in both 0% SFS groups. This result could be due to the increased secretion of cellulase and hemicellulase by the increased number of microorganism colonzations in the poultry hindgut as age increases (Janssen and Carre, 1989). Only ileal digestibility could distinguish between the digestibility by the poultry body system and microflora digestibility in the hindgut. Increased SFS fiber content and decreased CF digestibility did not affect the EE, nitrogen and other nutrient retention in the starter diet. The inclusion of up to 20% SFS produced comparable dressing percentage and percentage weights of liver and giblet. The abdominal fat percentage was increased at 15 and 20% SFS inclusion. This finding was expected as the EE contents of starter and finisher diet containing 20% SFS were higher. The higher dietary fat content could have increased the abdominal fat. Similarly, an increase in abdominal fat pad was reported for broilers fed 4 or 10% tallow in isocaloric and isonitrogenous diets (Deaton *et al*., 1981). The percentage skin weight based on live weight was decreased ($p<0.05$) in the groups fed = 10% SFS. This difference in percentage of skin weight can be attributed to the process of hot scalding during defeathering. This process might have increased the loss in skin fat of SFS-included groups as the carcass fat from groups fed unsaturated fats and oils has a lower melting point (Bartov *et al*., 1974).

CONCLUSION

The results of this study concluded that SFS can be used up to 20% in broiler diets without affecting the production performance and the dressing percentage. Because the AME of SFS and fat and fiber digestibilities of diets with SFS increased with age, it would be profitable to include SFS seeds in the finisher diet. Because the skin weight was reduced at 20% SFS inclusion, incorporation of saturated fat in the broiler diet might help to reduce the loss in skin weight.

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