Journal of Animal and Veterinary Advances 10 (16): 2061-2066, 2011
ISSN: 1680-5593

Performance, Nutrient Utilization and Carcass Characteristics and Economic Impact of Broiler Chickens Fed Extruded Bakery Waste

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Abstract: An experiment was carried out to evaluate the effects of replacing corn with extruded Bakery Waste (BWP) in a corn-soybean basal diet during the starter and finisher periods (day to 21 and 22-35 days of age, respectively) on the performance (weight gain, feed intake and feed conversion ratio), nutrient utilization (apparent nitrogen retention and nitrogen corrected apparent Metabolizable Energy (MEn)), carcass characteristics and cost of feed of broiler chickens. Six isocaloric and isonitrogenous diets were formulated using 0, 20, 40, 60, 80 and 100% of BWP. The levels of corn in the basal (0% BWP) starter and finisher diets were 53.7 and 62.78%, respectively. The replacement of dietary corn for up to 100% with BWP reduced costs of total feed and feed for the production of a kg live weight with no impairment on performance, nutrient utilization and carcass characteristics of broiler chickens. It is concluded that BWP can completely replace corn in broiler diets from day to 35 days of age. The substitution of corn with BWP offers economic benefits for both bakery and poultry producers.

Key words: Broilers, bakery waste, performance, nutrient utilization, carcass characteristics, corn-soybean

INTRODUCTION

The cost of feed is considered to be the main key factor in determining the profitability of poultry production. Approximately 60-80% of poultry production costs is feed with around 60% of each ration made from corn. Recent higher grain prices had an immediate impact on production costs of poultry where grain makes up a high proportion of their diets. This has reduced the profit margins to a very low level. In Saudi Arabia most of the basic feed ingredients are imported. Poultry producers are calling for higher poultry prices to cover the increasing cost of production as feed prices soar. These economic pressures have forced animal nutritionists to search for available alternative feed ingredients to battle the rise in feed costs.

Most of the research on animal feed is focusing on the use of by-products, upgrading of ingredients and enhancing productivity in order to reduce production costs. Bakery and kitchen wastes have been used as a nutritional supplement to the diet of animals on the basis of economic and environmental advantages. The American Association of Feed Control Officials identifies dried Bakery Waste Products (BWP) as an animal feed ingredient. Nutritionists and animal feed producers will choose ulternative feed ingredients if the quality and prices are competitive. There is a significant amount of leftover food in Saudi Arabia which represents ecological and health problems. Recently, Al-Ruqaie (2007) used extruded leftover food as a source in fish diet. BWP is a mixture of unsalable bakery products collected from bakeries. In Saudi Arabia, BWP, mostly as breads is available in a reasonable quantity for animal feeding. It includes Arabic bread, sandwich roll, burger, sliced bread, bread crumbs, cakes and cookies. The basic ingredients of bakery products in Saudi Arabia are wheat flour, oil (mostly palm oil), salt, shortening, sugar, yeast, chemical leavening agents and bread improvers (Mousa *et al*., 1992).

Results from different feeding trials with different classes of animals (cattle, steers, rats, rabbits and chickens) indicated that BWP was a satisfactory feed ingredient for animals (Harms *et al*., 1966; Day and Dilworth, 1968; Patrick and Schaible, 1980; Dale and Duke, 1987; Radwan, 1995; Saleh *et al*., 1996; El-Yamny *et al*., 2003; Al-Tulaihan *et al*., 2004; Ragab *et al*., 2006; Afzalzadeh *et al*., 2007). However, as with any feed ingredients their use depends upon their nutritional value. This study was designed to evaluate the nutritional value of extruded BWP as a replacement for corn in the diets of broiler chickens and its effects on on the performance, nutrient utilization, carcass characteristics and production costs.

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MATERIALS AND METHODS

BWP was collected from local commercial bakeries (mainly Arabic bread) in Riyadh area, screened to eliminate any mold contaminated materials, dried in a forced convection oven (Advantec, FG-220, Japan) at 65°C for 24 h then crushed into small pices and ground to powder using a grinder (Moline M-06, Italy) and 1.4 mm steel screen. The BWP powder was pelleted using a twin screw extruder (Model MPF19:25, APV-Baker UK) according to manufactory setting. The pelleting process was performed at a temperature of 70°C and pellets were 4 mm in diameter. The pellets were then crumbled in a roller mill. Samples of the BWP were analyzed in triplicate for moisture, protein, crude fiber, ether extract and ash according to the American Association of Cereal Chemists (AACC, 1994). Minerals were determined by wet ashing of flour samples as described by Osborne and Voogt (1978). Concentration of Na and K determined using an Eppendorf 700 flame photometer. Ca, Mg, Fe and Zn were determined using an IL, model 251 atomic absorption spectrophotometer. The total Phosphorus (P) was determined using the Vanadomolybdate calorimetric method. Amino acids were determined using High Performance Liquid Chromatography (HPLC, model 1993, Shimadzu, Japan) method as described in AOAC (1990). Chemical composition of the BWP is shown in Table 1.

The proximate analysis of BWP compared to corn (NRC, 1994) indicates that the BWP contains more energy (as measured by TMEn) and protein than corn. In addition, the amino acid profile of BWP compares favorably to corn and is complementary to the amino acid profile of soybean meal which is used as a protein source in broiler chicken diets. Most essential amino acids such as lysine, methionine, phenylalanine, tyrosine, isoleucine, thereonine, arginie and histidine are higher and leucine and valine were lower in BWP compared to corn.

A total of 180, day old Ross male broiler chickens were individually weighed and randomly sorted into 36 replicates to minimized differences in body weight between replicates with 5 birds each. They were housed in electrically heated battery cages. Lighting was incandescent and continuous throughout the experimental period. Six replicates were randomly assigned to either one of six starter diets to 21 days followed by finisher diets to 35 days of age. The six starter and finisher included a control corn based diet with 0% BWP and five different diets using 20, 40, 60, 80 and 100% BWP to replace corn in the basal diet. The levels of corn in the basal (0% BWP) starter and finisher diets were 53.7 and 62.78%, respectively. Acid washed sand (10 g kg $^{-1}$) was added to the diet as a source of Acid Insoluble Ash (AIA). Sand with particle size of 40 mesh (~595 μm) was soaked in 4 N HCL for a day and washed thoroughly to remove all acid. Sand was then oven dried at 100°C, cooled and stored for inclusion in the diet. The experimental diets were formulated to be isocaloric and isonitrogenous (Table 2). Feed and water were available *ad libtium*. Excreta samples were collected every 12 h from 18-21 days of age from three randomly selected replicates of birds from each dietary treatment. Trays lined with plastic sheets were fitted under the cages for excreta collection. After removing feathers, feed residues and other contamination sources, excreta from each experimental unit were collected early in the morning and in the evening. Feed and excreta samples were oven dried at 80°C and finely ground prior to analysis. Nitrogen (N) in both feed and excreta was determined by Kjeldahl procedure (AOAC, 1990), gross energy by using an adiabatic bomb calorimeter and AIA by Dourado *et al*. (2010). The calculations of nutrient utilization as described by Scott *et al*. (1982) were as follows:

Table 1: Comparison of approximate analysis, amino acids and minerals profile of Bakery Waste Products (BWP) and corn

Aproximate analysis	BWP	Corn (NRC, 1994)
TMEn (kcal g^{-1})[1]	3.854	3.470
Approximate analysis (g kg^{-1})		
Moisture	63.600	110.000
CP	129.300	85.000
Ether extract	15.900	38.000
Crude fiber	5.300	22.000
Ash	15.300	12.000
Amino acids profile (%)		
Essential amino acids		
Lysine	0.310	0.260
Methionine	0.260	0.180
Phenylalanine	0.750	0.380
Tyrocine	0.340	0.300
Leucine	0.570	1.000
Isoleucine	0.490	0.290
Valine	0.340	0.400
Thereonine	0.510	0.290
Arginine	0.460	0.380
Histidine	0.280	0.230
Non-essential amino acids		
Aspartic acid	0.740	-
Alanine	0.280	-
Serine	0.700	0.370
Glutamic acid	4.720	-
Glycine	0.510	0.330
Minerals profile (mg/100 g)		
Calcium	178.000	20.000
Phosphorus	198.000	280.000
Sodium	440.000	20.000
Potassium	160.000	300.000
Magnessium	60.000	120.000
Zinc	97.000	1.800
Iron	52.000	4.500

[1]True Metabolizable Energy (TME) was calculated according the following equation of Dale *et al.* (1990): TME (kcal kg^{-1}) = 4,340-100× CF-40× Ash-30× CP+10× EE (Dale *et al.*, 1990)

$$\text{Apparent N Retention (ANR)} = 100-(100\times F^{*}\times F^{**})$$

Where:

F* = Percentage of AIA in diet/Percentage AIA in excreta

F** = N in Excreta (mg g $^{-1}$)/N in diet (mg g $^{-1}$)

Table 2: Composition of the experimental diets (g kg^{-1})[1]

	Replacement level of bakery waste products (%)											
	Starter phase (1-21 days of age)						Finisher phase (21-35 days of age)					
Diets	0	20	40	60	80	100	0	20	40	60	80	100
Corn	537.000	428.600	322.000	214.300	107.200	0.000	627.800	502.100	376.500	251.200	125.600	0.000
Bakery waste product	0.000	107.200	214.300	321.500	428.600	537.000	0.000	125.600	251.200	376.500	502.100	627.800
Soybean meal	364.900	364.000	349.300	334.200	319.100	321.900	297.200	280.700	264.300	247.900	248.600	230.000
Bran	0.000	3.800	21.500	40.000	58.200	44.500	1.200	21.900	41.280	63.060	62.600	86.500
Corn oil	49.700	48.300	45.500	43.000	40.400	40.400	36.100	33.000	29.800	26.700	27.000	22.600
Sand	10.000	10.000	10.000	10.000	10.000	20.000	0.000	0.000	0.000	0.000	0.000	0.000
Limestone	13.700	13.300	12.900	12.600	12.200	11.500	14.000	13.500	13.100	12.700	12.100	11.700
Dicalcium phosphate	17.100	17.300	17.200	17.100	17.100	17.700	17.600	17.600	17.800	17.400	17.600	17.600
Salt	3.400	2.800	2.200	1.600	1.000	0.500	3.400	2.700	2.100	1.300	0.700	0.000
Premix[1]	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
DL-Methionine	2.000	2.200	2.300	2.500	2.600	2.800	0.700	0.900	1.900	1.200	1.400	1.500
L-Lysine	0.200	0.500	0.800	1.200	1.600	1.700	0.000	0.000	0.020	0.040	0.300	0.300
Analysis												
ME (kcal g^{-1})[2]	3.172	3.203	3.182	3.162	3.192	3.213	3.179	3.169	3.149	3.166	3.171	3.189
CP (N%×6.25)[3]	22.800	22.900	22.600	23.100	22.600	23.100	20.080	20.230	19.970	20.200	20.190	20.340
Calcium (g kg^{-1})	9.800	10.100	10.100	9.900	10.000	10.200	10.200	10.000	10.100	10.000	9.900	10.000
AP (g kg^{-1})[4]	5.000	5.000	5.000	5.000	5.000	5.000	4.500	4.500	4.500	4.500	4.500	4.500
Lysine (g kg^{-1})	13.300	13.300	13.300	13.300	13.300	13.300	10.000	10.000	10.000	10.000	10.000	10.000
Met+Cys (g kg^{-1})[5]	9.300	9.300	9.300	9.300	9.300	9.300	7.200	7.200	7.200	7.200	7.200	7.200

[1]The composition of vitamins and minerals in the premix (per ton of diet: vitamin A, 6000,000 IU; vitamin D, 1500,000 IU; vitamin E, 20,000 IU; vitamin K 1,000 mg; vitamin B1, 1 mg; vitamin B2, 3000 mg; vitamin B6, 2000 mg; vitamin B12, 10 mg; niacin, 20,000 mg; folic acid, 500 mg; pantothenic acid 5,000 g; biotin, 50 mg; antioxidant, 60.000 mg; cobalt, 100 ppm; copper, 5,000 ppm; iodine, 500 ppm; iron, 20.000 ppm; manganese, 40.000 ppm; selenium, 100 ppm; zinc, 30.000. [2]ME = Metabolizable energy; [3]CP = Crude Protein; [4]AP = Available Phosphorus was calculated on the basis of 30% availability of phosphorus in plant products; [5]Met+Cys = Methionine+Cysteine

$$\text{N corrected Apparent Metabolizable Energy } (AME_n) = \text{Energy g diet}^{-1} - \text{Excreta energy g diet}^{-1} + 8.22\times\text{mg N retained g diet}^{-1}$$

Where:

Excreta energy per g diet = Energy per g excreta×F*

N retention (mg g^{-1} diet) = N in diet (mg g^{-1})−N in excreta (mg g^{-1})×F*

At the end of the experiment, six birds per diet were randomly selected and processed at King Saud University to determine processing yields and carcass quality. Measurements were made of body weight gain, feed intake and feed conversion ratio from 1-35 days of age, nutrient utilization (Apparent N Retention (ANR)), N corrected Metabolizable Energy (AME_n)) between 18 and 21 days of age and carcass composition at 35 days of age. The costs of total feed intake and feed for the production of a kg live weight during the starter and finisher periods were calculated. Data collected were subjected to analysis of variance using GLM procedures (SAS, 1988). Where significant variance ratios were detected, differences between treatment means were tested using the Least Significant Difference (LSD) procedures.

RESULTS AND DISCUSSION

The effects of replacing dietary corn with BWP on the performance, carcass characteristics, nutrient utilization and costs of total feed and feed for the production of a kg live weight of broiler chickens are shown in Table 3 and 4 and Fig. 1 and 2, respectively. The replacement of dietary corn for up to 100% with BWP did not influence body weight gain, feed intake and carcass characteristics at 35 days of age, feed intake and FCR during the starter and finisher periods (day to 21 and 22-35 days of age, respectively) and nutrient utilization (ANR and AME_n) between 18 and 21 days of age of broiler chickens. However, chickens fed 60 and 100% BWP diets had a higher weight gain when compared with those fed 0% BWP diet at 21 days of age and chickens fed 20% BWP diet had a lower FCR when compared with those fed 0, 80 and 100% BWP diets at 35 days of age. These results suggested that BWP could replace 100% of the corn in broiler diets without any adverse effects on the performance when corn was used at levels of 53.7 and 62.78% in the starter and finisher diets, respectively. However, Damron *et al*. (1965), Day and Dilworth (1968), Saleh *et al*. (1996) and Al-Tulaihan *et al*. (2004) suggested that the maximum dietary level of BWP in broiler diets were at 10, 15, 25 and 30%, respectvely. Differences in the maximum dietary level of BWP reported in these studies may be a result of a number of factors including variability in nutrient composition and quality of BWP used in these studies. The variability in nutrient composition of BWP is considered to be the biggest challenge when incorporating BWP into poultry diets (Waldroup *et al*., 1982; Dale and Duke, 1987; Dale and Fuller, 1987). This

Table 3: The performance and nutrient utililization of broiler chickens fed graded levels of Bakery Waste Products (BWP) as a replacement for corn in their diets

	Replacement level of BWP (%)						
Performance and nutrient utililization	0	20	40	60	80	100	pr>f
Performance of chickens							
Feed intake during the starter period (g, 1-21 days)	1252.000	1229.600	1252.800	1297.300	1278.900	1301.600	0.3774
Feed intake during the finisher period (g, 22-35 days)	2128.600	2060.100	2067.700	2075.500	2124.400	2185.800	0.2895
Total feed intake (g, 1-35 days)	3380.600	3289.700	3320.500	3372.800	3403.300	3487.500	0.2895
Weight gain during the starter period (g, 1-21 days)	856.800^{b}	911.800^{ab}	894.200^{ab}	934.400^{a}	907.000^{ab}	938.800^{a}	0.0291
Weight gain during the finisher period (g, 22-35 days)	1279.600	1290.400	1247.000	1234.600	1224.200	1258.200	0.6767
Total weight gain (g, 1-35 days)	2136.400	2202.200	2141.000	2169.000	2131.200	2197.000	0.5333
Feed conversion ratio during the starter period (1-21 days)	1.462	1.353	1.402	1.388	1.411	1.387	0.3913
Feed conversion ratio during the finisher period (22-35 days)	1.664	1.601	1.663	1.681	1.737	1.737	0.0636
Feed conversion ratio from 1-35 days	1.583^{a}	1.494^{b}	1.553^{ab}	1.555^{ab}	1.597^{a}	1.587^{a}	0.0406
Nutrient utilization (between 18-21 days)							
Apparent Nitrogen Retention (ANR, %)	64.800	64.100	62.900	63.500	64.200	63.200	0.1797
Nitrogen correted metabolizable energy (AMEn, kcal kg^{-1})	3098.000	3112.000	3077.000	2999.000	3203.000	3073.000	0.3610

^{a,b}Means within raw followed by different superscripts are significantly different (p<0.05)

Table 4: Carcass characteristics of broiler chickens at 35 days of age fed graded levels of Bakery Waste Products (BWP) as a replacement for corn in their diet

	Replacement level of corn with BWP (%)						
Body composition	0	20	40	60	80	100	pr>f
Live body weight (g)	2268.8	2365.0	2226.2	2243.3	2258.0	2290.5	0.2261
g kg^{-1} live body weight							
Carcass weight	781.0	810.9	807.5	818.6	799.1	792.9	0.3694
Abdominal fat	8.8	7.9	11.5	9.7	10.0	16.9	0.3207
Edible offal[1]	46.4	41.8	42.0	38.0	38.5	36.9	0.5153
Eviscerated carcass	725.8	761.2	754.0	770.9	750.6	739.1	0.3030
g kg^{-1} eviscerated carcass							
Breast	482.2	476.2	473.9	468.1	463.6	475.9	0.9881
Back	180.1	190.2	193.9	177.9	182.7	175.6	0.0921
Drums plus thigh	293.7	284.1	281.0	301.8	301.7	297.2	0.4699
Wings	44.0	49.6	51.1	52.1	52.0	51.3	0.3647

[1]Edible offal = Liver+heart+gizzard

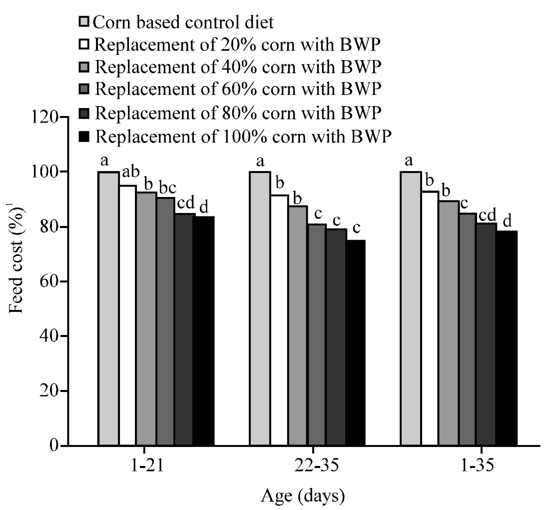

Fig. 1: The cost of broiler chicken fed graded dietary levels of Bakery Wastes Products (BWP) as a replacement for corn from 1-35 days of age; [1]The feed cost of experimental diets were compared to the corn based control diet; the feed cost of the corn based control diet was considred to be 100%; $^{a-c}$Columns with different superscripts are significantly different (p<0.05)

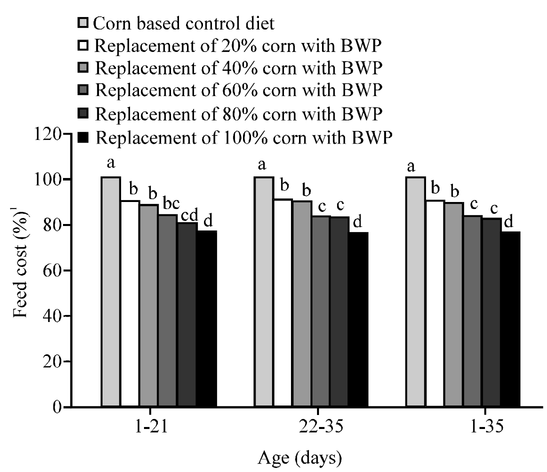

Fig. 2: Feed cost for the production of a kg live weight of broiler chickens fed graded ietry level of Bakery Wastes Products (BWP) as a replacement for corn from 1-35 days of age; [1]The feed cost of experimental diets were compared to the corn based control diet; the feed cost of the corn based control diet was considred to be 100%; $^{a-c}$Columns with different superscripts are significantly different (p<0.05)

variability depends on the relative amounts of different types of bakery products and the nutrient composition of each product. Significant differences in the chemical composition of BWP samples were reported in the literature, especially for sodium. Excess dietary sodium are toxic to chickens (Patrick, 1980; Austic and Scott, 1997). Thomas *et al.* (1981) found that sodium content of BWP ranged from 1.8-3.4%. Whilst, Saleh *et al.* (1996) and Al-Tulaihan *et al.* (2004) reported that sodium levels of BWP were at 0.93 and 3.2%, respectively. However, sodium content of BWP used in this study was 0.22% (Table 1). In Saudi Arabia, there are six different types of local breads; namely, samouli, mafrood, burr, tannouri, tamees and korsan, commercially baked from wheat flour. The sodium contents of these breads ranged from 0.066-0.301% (Mousa *et al.*, 1992). It appears that BWP of Saudi breads contains lower amount of sodium when compared with those of BWP reported in the literature. The lower sodium content of BWP used in this study allowed for the inclusion of a higher level of BWP in the diets of broiler chickens than those reported by other studies. If the BWP comes from a single type of bread, the BWP will be relatively homogeneous, the variability of BWP will be less than a situation with bakery from a variety of sources. In the case of the former, higher inclusion rates of BWP are acceptable than in the case of the latter.

Costs of total feed intake and feed for the production of a kg live weight of chickens during the period from 1-35 days of age were significantly ($p<0.01$) reduced by the substitution of corn with BWP in the diet (Fig. 1 and 2, respectively). Costs of feed intake and feed for the production of a kg live weight of chickens at 35 days of age were significantly ($p<0.01$) reduced by approximately 7.3 and 10.0; 10.9 and 11.0; 15.9 and 16.9; 18.6 and 18.4 and 21.9 and 24.0% for diets with 20, 40, 60 80 and 100% BWP, respectively, when compared with those fed the corn basal diet (0% BWP). Diets with 100% BWP reduced cost of feed during the age periods from 1-21 and 1-35 when compared with those of 0, 20, 40 and 60% BWP diets and from 22-35 days of age when compared with those of below 60% BWP diets, diets with 100% BWP reduced feed cost of the production of a kg live weight of chickens during the age periods from 1-21when compared with those of 0, 20, 40 and 60% BWP diets and from 22-35 and 1-35 days of age when compared with any other diet.

CONCLUSION

Results from this experiment suggest that BWP can completely replace corn in broiler diets from day to 35 days of age without adversely affecting feed intake, nutrient utilization, body weight gain and carcass characteristics. The evaluated BWP had higher protein and a slightly lower gross energy contents when compared with those of corn. It represents an alternative resource capable of replacing corn in broiler diets. The substitution of corn with BWP reduced feed cost and improved profit margin.

ACKNOWLEDGEMENTS

The researchers would like to express their sincere appreciation to the King Abdulaziz City for Science and Technology (KACST) for the generous financial support provided for this research project through grant number 28-126. Special thanks are extended to the Deanship of Scientific Research and Agriculture Research Center of King Saud University for support in conducting this study.

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