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Performance, Egg Characteristics and Economic Impact of Laying Hens Fed Extruded Bakery Waste

[1]T.M. Shafey, [1]M.A. Alodan, [1]H.A. Al-Batshan, [2]M.A. Abouheif, [1]M.S. Alamri and [2]I.M. Al-Ruqaie
[1]Department of Animal Production, College of Food and Agriculture Sciences,
King Saud University, Riyadh, Saudi Arabia
[2]The National Center for Agriculture Technology, King Abdulaziz City for Science and Technology,
P.O. Box 6086, 11442 Riyadh, Saudi Arabia

Abstract: An experiment was carried out to evaluate the effects of replacing corn with extruded Bakery Waste (BWP) in the diet of laying hens on the performance (feed intake, egg production, egg weight, egg mass and feed efficiency) and egg components (albumen, yolk and eggshell) and characteristics of eggshell (thickness and strength) and albumen (height and Haugh unit) and yolk (height and color (YH and YC)) and feed costs of egg production. Six isocaloric and isonitrogenous diets were formulated using 0, 20, 40, 60, 80 and 100% of BWP. The level of corn in the basal diet (0% BWP) was 60.16%. The replacement of corn for up to 100% with BWP reduced feed costs with no impairment on the performance, egg components, characteristics of eggshell and albumen and YH. Replacing dietary ≥40% of corn with BWP reduced YC. It is concluded that BWP can completely replace corn in laying hen diets without affecting the performance, egg components, egg characteristics of albumen and eggshell and YH. Yolk pigment should be added to the diet to improve YC when ≥40% of corn replaced with BWP.

Key words: Laying hens, bakery waste, egg production, egg characteristics, feed costs, Saudi Arabia

INTRODUCTION

Over the past two decades, the egg industry in Saudi Arabia has expanded considerably, fueled by the increased demand of a growing population for highly nutritious and affordable poultry eggs. However, the continued sustainability and growth of Saudi's egg sector will depend upon the cost of egg production. Feed is the largest component, representing approximately 60-80% of the economic inputs in the commercial poultry industry. Consequently, feed prices can have a dramatic impact. Corn is the main source of energy in formulating poultry rations. Higher corn prices driven by ethanol production are changing the cost of egg production. Small changes in feed ingredient selection and diet formulation can have large effects on the cost of production and prices sustainability at a profitable level. Poultry nutritionists are under pressure to keep feed costs under control while maintaining top production performance. Many local ingredients and leftover foods are available for consideration in the inclusion of dietary formulation. Al-Ruqaie (2007) used extruded leftover food as a source in fish diet. Recently, Al-Ruqaie *et al.* (2011) found that extruded Bakery Waste Products (BWP) could replace corn in broiler diets without any impairment on performance. The substitution of corn with BWP in broiler diet reduced costs of the diets and consequently production of chickens (Radwan, 1995; El-Yamny *et al.*, 2003; Al-Ruqaie *et al.*, 2011). The increase in available BWP and the need for poultry producers to enhance profitability make the use of BWP more important than in the past. The objective of this study was to evaluate the effect of replacing corn with BWP in laying hen diet on the performance, egg characteristics and feed cost of egg production.

MATERIALS AND METHODS

BWP was collected from local commercial bakeries (mainly Arabic bread) in Riyadh area and treated as previously mentioned (Al-Ruqaie *et al.*, 2011). 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). Chemical composition of the BWP is shown in Table 1. Results from the chemical analysis of BWP samples in this study and earlier study (Al-Ruqaie *et al.*, 2011) indicate that BWP is uniform in composition. It contains more

Corresponding Author: T.M. Shafey, Department of Animal Production, College of Food and Agriculture Sciences,
King Saud University, P.O. Box 2460, 11451 Riyadh, Saudi Arabia

protein and energy and lower fiber when compared to corn (Table 1). A total of 48 Hi-sex laying hens, 44 weeks of age kept individually in battery cages were used in the trial. Each bird was treated as an experimental unit. Eight replicates were randomly assigned to either one of six experimental diets. The experimental diets 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 level of corn in the basal diet (0% BWP) was 60.61%, respectively. The composition of the basal and experimental diets is shown in Table 2. The experiment lasted 10 weeks. Egg production and feed intake were recorded for each replicate. Feed and water were available *ad libitum*. A photoperiod of 16 h was maintained throughout the trial. Calculations of feed consumption were based on a 2nd week period and characteristics of eggs were based on a complete egg collection for one day each week. Characteristics of eggs include egg weight, egg components (albumen, yolk and eggshell) and eggshell (thickness and strength), albumen (height and Haugh units) and yolk (height and color).

Table 1: Comparison of approximate analysis of Bakery Waste Products (BWP) and corn

Contents	BWP	BWP (Al-Ruqaie *et al*., 2011)	Corn (NRC, 1994)
TMEn (kcal g^{-1})	3.863	3.854	3.470
Approximate analysis (g kg^{-1})			
Moisture	71.600	63.600	110.000
CP	124.300	129.300	85.000
Ether extract	14.600	15.900	38.000
Crude fiber	5.900	5.300	22.000
Ash	14.800	15.300	12.000

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

Measurements of characteristics of eggs: Each egg was initially weighed using an egg analyzer™ (Sanovo Engineering, Odense NV, Denmark) and shell breaking strength was determined and recorded by eggshell force reader (Sanovo Engineering, Odense NV, Denmark) then the egg was broken and egg contents (albumin and yolk) were placed on the measuring tray of the egg analyzer™ (Sanovo Engineering, Odense NV, Denmark) for the determination of albumen height, Haugh units (Haugh, 1937) and yolk color. Haugh units were automatically calculated within the system on the input of egg weight and albumen height. Yolk height was measured on the tray using an Ames tripod micrometer (Ames, Waltham, MA, USA).

The yolks were separated from the egg analyzer tray (albumen and yolk) using a Teflon spoon. Before the yolk weight was determined, the chalaza was removed with a spatula. Eggshells washed with water, dried with paper towels and then weighed. Albumen weight was calculated by subtracting the weights of yolk and eggshell from the weight of the egg. Three measurements of shell thickness including eggshell membranes were taken from the large end, equator and small end of each eggshell with a micrometer (Ames, Waltham, MA).

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

	Replacement level of bakery waste products (%)					
Feed ingredients	0	20	40	60	80	100
Corn	601.600	481.300	361.300	240.600	120.300	00.000
Bakery waste products	0.000	120.300	240.600	361.300	481.300	601.600
Soybean meal	223.900	226.400	226.600	220.400	204.700	185.200
Bran	30.000	30.000	40.000	50.000	70.200	80.000
Corn oil	8.900	7.600	5.900	3.500	00.000	00.000
Gluten meal	20.000	11.300	00.900	00.000	00.000	00.000
Sand	9.200	15.000	20.000	20.000	20.000	29.100
Limestone	80.000	82.000	79.200	78.700	78.300	78.700
Dicalcium phosphate	18.000	18.000	18.000	18.100	18.000	18.100
Salt	4.100	3.500	2.800	2.200	1.500	0.900
Premix[1]	2.000	2.000	2.000	2.000	2.000	2.000
DL-Methionine	0.900	1.200	1.500	1.600	1.800	2.000
L-Lysine	1.400	1.400	1.200	1.600	1.900	2.400
Calculated nutrient composition[2]						
ME (kcal g^{-3})	2.800	2.800	2.800	2.800	2.800	2.800
CP (N%×6.25)[4]	18.000	18.000	18.000	18.000	18.000	18.000
Calcium (g kg^{-1})	35.000	35.000	35.000	35.000	35.000	35.000
AP (g kg^{-1})[5]	5.000	5.000	5.000	5.000	5.000	5.000
Lysine (g kg^{-1})	10.000	10.000	10.000	10.000	10.000	10.000
Met+Cys (g kg^{-1})[6]	7.000	7.000	7.000	7.000	7.000	7.000

[1]The composition of vitamins and minerals in the premix (per kg of diet): vitamin A, 6000 IU; vitamin E, 10 IU; menadione, 2.5 mg; Vitamin. D, 2000 ICU; riboflavin, 2.5 mg; Ca pantothenate, 10 mg; nicotinic acid, 12 mg; choline chloride, 500 mg; vitamin B_{12}, 4 μg; vitamin B_6, 5 mg; thiamine, 3 mg; folic acid, 0.50 mg; biotin, 0.2 mg; Zn, 40 mg; Fe, 40 mg; Cu, 4 mg; Se, mg 0.10; carrier (pollard) made up to 2g; [2]calculated values from NRC (1994); [3]ME = Metabolizable Energy; [4]CP = Crude Protein; [5]AP = Available Phosphorus was calculated on the basis of 30% availability of phosphorus in plant products. [6]Met+Cys = Methionine+Cysteine

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 basic ingredient of bakery products in Saudi Arabia is wheat flour (Mousa *et al*., 1992). The effects of replacing corn with BWP in the diet of laying hens on the performance (feed intake, rate of egg production, egg weight, egg mass, feed conversion (g feed/g egg)) and egg components and characteristics of eggshell (thickness and strength), albumen (height and Haugh unit) and yolk (height and color) and costs of diets and feed for egg production are shown in Table 3 and 4 and Fig. 1, respectively.

The substitution of corn with BWP in the diet of laying hens did not influence the performance, egg components, characteristics of eggshell and albumen and yolk height. However, increasing dietary level of BWP significantly ($p<0.01$) reduced egg yolk color (0%BWP = 20%, BWP>40% = 60%, BWP>80%, BWP >100% BWP). These results were in agreement with Lazaro *et al*. (2003), Ciftci *et al*. (2003) and Cufadar *et al*. (2010) who concluded that wheat can be used instead of corn as an energy feedstuff in laying hen diets without affecting performance or egg quality except for egg yolk egg yolk color. Egg yolk color was lower with wheat-based diets when compared with those of corn-based diets (Saha *et al*., 1998; Ciftci *et al*., 2003; Cufadar *et al*., 2010).

In the present study, the egg yolk color decreased with increasing replacement level of corn with BWP (40% and above) when compared to the control diet (0% BWP). Yolk pigmentation results primarily from carotenoid pigments especially xanthophylls, provided in the diet of laying hens. Since, birds do not synthesize pigments in their physiological system (Marusich and Bauernfeind, 1981). The lower egg yolk pigmentation of BWP diets is due to the low xanthophylls content of the

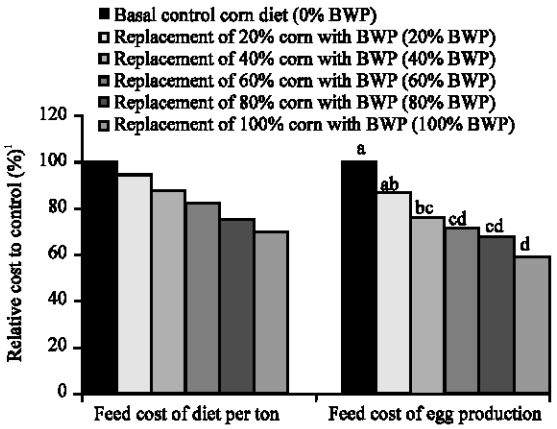

Fig. 1: Relaitive costs of diets and feed for egg production of laying hens fed graded levels of Bakery Waste Products (BWP) as a replacement of corn. The feed cost of experimental diets and egg production were compared to the basal control diet (0% BWP) on the basis of 100%; [a-c]columns with different superscripts are significantly different ($p<0.05$)

Table 3: Performance and egg components of laying hens fed graded dietary levels of Bakery Waste Products (BWP) as a replacement for corn in their diets[1]

Replacement level of BWP (%)	Feed intake (g)	Egg production (%)	Egg weight (g)	Egg mass (g day^{-1})	Feed conversion (g feed/g egg)	Egg components (%)		
						Albumen	Yolk	Shell
0	114.2	88.1	60.6	53.5	2.19	63.0	27.3	9.7
20	112.1	90.7	61.3	55.7	2.03	62.5	27.5	10.0
40	112.8	92.9	63.7	59.2	1.90	63.3	27.00	9.7
60	110.4	91.4	63.7	58.3	1.91	63.4	26.70	9.9
80	110.3	91.3	61.8	56.4	1.96	62.9	27.20	9.9
100	103.6	92.2	60.8	56.0	1.85	62.5	27.60	9.9
p<0.05	0.7731	0.6910	0.4262	0.4271	0.3795	0.2332	0.2122	0.2936

[1]The level of corn in the basal diet (0% BWP) was 60.16%

Table 4: Characteristics of egg components of laying hens fed graded dietary levels of Bakery Waste Products (BWP) as a replacement for corn in their diets[1]

	Albumen		Yolk		Eggshell	
Replacement level of BWP	Height (mm)	Haughunit	Height (mm)	Color	Thickness (mm)	Force (kg cm^{-2})
0	53.8000	65.4000	25.3000	7.4000^{a}	38.8000	3.2000
20	48.8000	62.2000	21.4000	7.3000^{a}	38.9000	3.4000
40	49.0000	59.7000	24.6000	6.2000^{b}	37.8000	3.2000
60	54.8000	65.7000	26.4000	5.9000^{b}	37.9000	3.6000
80	49.0000	59.8000	23.9000	4.6000^{c}	38.1000	3.3000
100	52.7000	60.6000	27.0000	3.7000^{d}	38.2000	3.5000
p<0.05	0.3515	0.1519	0.0872	0.0001	0.0638	0.4283

[1]The level of corn in the basal diet (0% BWP) was 60.16%; [a,b]means within column followed by different superscripts are significantly different ($p<0.05$)

BWP when compared with corn. The lower xanthophylls content of the BWP can be easily balanced in the rations with other sources of egg yolk pigments such as marigold oil, yeast products, synthetic compounds and even corn-based distillers dried grains with soluble (Dufosse, 2006). These yolk pigments are widely available and often can be included in rations on a least cost basis. Consumers prefer yolk color ranging from yellow to orange (Vuilleumier, 1969).

The BWP price is approximately 60% of corn price. The replacement of corn with BWP in the diets of laying hens reduced the cost of the diet by approximately 6.1, 12.9, 18.3, 24.7 and 30.2% for 20, 40, 60, 80 and 100% BWP diets, respectively. Whilst the cost of feed for egg production was significantly reduced by 13.2, 24.6, 28.8, 32.7 and 41.2% for 20, 40, 60, 80 and 100% BWP diets, respectively when compared with those fed the corn basal diet (0% BWP, Fig. 1). Replacing 100% of corn with BWP significantly ($p<0.01$) reduced feed cost of egg production when compared with those of 0, 20 and 40% BWP. There was no significant difference in feed cost for egg production among 60, 80 and 100% BWP diets. The replacement of corn with BWP in laying hens diets reduced costs and consequently increased profits. Similar findings were reported when BWP replaced corn in diets of growing chickens (Radwan, 1995; El-Yamny *et al*., 2003; Al-Ruqaie *et al*., 2011). While current industrial processes of grains will continue to influence prices and availability of grains as feed ingredients, poultry nutritionists will keep looking for alternate ingredients that are very much dependent on supply of ingredients from various industrious wastes and processes.

CONCLUSION

It is concluded that BWP can completely replace corn in laying hen diets without affecting the performance, egg components and characteristics of albumen and eggshell. The substitution of 40% and above of dietary corn content (601.6 g kg^{-1} diet) with BWP reduced egg yolk color and yolk pigment supplements should be added to the diet to improve yolk color that meet consumer preferences.

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