Pakistan J. Zool., vol. 47(4), pp. 1059-1066, 2015.

Effect of Feeding Hatchery Waste Meal Processed by Different Techniques on Egg Quality and Production Performance of Laying Hens

Athar Mahmud,[1,*] Saima,[1] Makhdoom Abdul Jabbar,[1] Abdul Waheed Sahota,[1] Zafar Hayat[2] and Muhammad Zafar Ullah Khan[1]

[1]University of Veterinary and Animal Sciences, Lahore, Pakistan

[2]Department of Animal Sciences, University of Sargodha, Sargodha, Pakistan

Abstract: - Three hundred White Leghorn hens were randomly divided into 10 groups. One group was fed control diet prepared without hatchery waste meal (HWM), while nine groups were fed on experimental diets containing 4, 8 or 12 % of cooked, autoclaved or extruded HWM, respectively. Results showed that maximum egg production was achieved with 4% HWM processed by autoclaving. Processing of hatchery waste (HW) with extrusion significantly reduced egg production and more pronounced decrease was found with 12 % of extruded HWM. Egg mass and feed conversion followed the same trend observed for egg production. Average egg weight due to different treatments fell within very narrow range and showed no difference (P>0.05) among them. Shell, yolk and albumen weights, as a percentage of egg weight, were not significantly affected with the use of different levels and processing of HWM. Maximum value of albumen height as well as Haugh units were obtained with the feeding of 4 % autoclaved HWM. Other egg quality parameters like shell thickness, yolk index and color were independent of the dietary treatments. The findings of this study suggest that autoclaving of hatchery waste is better than extrusion and cooking techniques and 4 % of autoclaved HWM may be included in layers ration for improve production than diets without HWM. Nevertheless, layer diets up to 8 % HWM could be used to feed the laying hens to maintain reasonably good production without detrimental effects on egg quality.

Key words: Egg quality, hatchery wastes, production performance of layers.

INTRODUCTION

Tremendous growth of the poultry industry is accompanied by the production of large quantities of by-products particularly hatchery wastes (Das *et al*., 2002). Hatchery waste (HW) consists of infertile whole eggs, dead chicks, broken egg shells and low grade unsalable chicks (Hamm and Whitehead, 1982). HW in its natural state contains about 44.3% crude protein, 30.0% ether extract, 1.90% crude fiber, 14.0% ash, 4572 Kcal/Kg gross energy and 3600 Kcal/Kg metabolizable energy (Rasool *et al*., 1999). It is rich in calcium but low in phosphorus contents (Dufloth *et al*., 1987). Calcium level depends on the presence of shell moiety and hatch percentage.

The disposal of hatchery waste is of serious concern for the poultry industry (Deshmukh and Patterson, 1997). Traditional methods of HW disposal include landfills, land application, rendering, composting and incineration (Miller, 1984; Blake and Donald, 1992; Carr *at al*., 1992; Das *et al.*, 2002). Fresh HW has high moisture content (67%) making it highly perishable which requires frequent hauling due to poor storage facilities at the hatchery. Therefore, disposal of HW is very costly to the producers and unsafe for the environment in general (Deshmukh and Patterson, 1997; Shahriar *et al.*, 2008). A very efficient and cost-effective method for the disposal of HW is to recycle it to produce a hatchery waste meal (HWM) for inclusion in poultry rations, provided this feed component does not negatively affect the productive performance of birds. Raw HW contains a number of viable bacteria, so before inclusion in poultry feeds it should be properly processed to reduce the microbial count.

Researchers have explored various methods for processing HW. These methods include cooking, autoclaving and extrusion. Considering the quantity of HW available and its chemical composition, it can be used as a source of protein and calcium for all classes of poultry (Blake, 1998). However,

* Corresponding author: atharmahmud@uvas.edu.pk
0030-9923/2015/0004-1059 $ 8.00/0

feeding HWM to layers is not well documented. Not much information regarding the maximum inclusion level of HWM in the layer diets is available. The present study was aimed at investigating the effects of feeding HWM processed by different techniques on the egg quality and production performance of laying hens.

MATERIALS AND METHODS

Processing of hatchery waste

For different processing techniques, hatchery waste was procured from a local hatchery. The raw HW as well as processed HWM (simple cooking, autoclaving and extrusion cooking was subjected to chemical analysis.

Simple cooking

The HW was processed by simple cooking in water in such a way that there was double the amount of HW to water (2:1) (Khan and Bhatti, 2001). The moisture percentage of HW before adding water was 67%. The simple cooking process continued for about three hours at 100^{o}C in an open container with regular stirring till extra moisture was evaporated. Then this dehydrated product was placed in an oven for drying at 60°C till constant weight and ground through a laboratory mill for further analysis.

Autoclaving

In this method, the dried and ground HW was subjected to 125°C temperature along with 1.76 Kg/cm^2 pressure for 15 minutes. After this, the material was sealed to avoid the growth of microorganisms. This atutoclaved meal was used for further chemical analysis (Lilburn *et al.,* 1997).

Extrusion cooking

In this technique, the dried and ground hatchery waste was passed through dry extruder using a single screw extruder (Model 1000-4 Miltenz Auckland, NZ, frequency, 50 Hz., orifice size, 8-12 mm., screw speed, 536 rpm., feed rate, 750 kg/h). The internal temperature of the extruder barrel was 115 to 126^{o}C at the point of extrusion. The final extruded product was collected on polythene sheet (Haque *et al.,* 1991) and stored for analyses and to be used in the experimental rations.

After drying the representative samples of the HWM prepared from the above mentioned processing techniques were subjected to proximate analysis (AOAC, 2000).

Birds and housing

A feeding trial of twelve weeks was conducted to determine the optimum inclusion level of HWM in layer diets at poultry experiment station of the University. Three hundred Single Comb White Leghorn (SCWL) hens of 21 weeks of age were purchased and divided into 30 experimental groups under Completely Randomized Design (CRD). Ten laying hens were housed in one experimental cage (two tiered providing 470 cm^2 per hen) treated as one replicate and were fed as a group. Layers were maintained on a 16h light: 8h dark regimes. Standard norms of husbandry and management practices like ventilation, sanitation, lighting schedule and vaccination were followed uniformly for all experimental groups. This practice continued till the end of 36 weeks.

Experimental diets

The experimental birds were randomly allotted 10 experimental diets having three replicates in each diet. For the first two weeks layer mash was provided, then during 24 to 36 weeks of age, birds were given experimental ration and data were collected. Experimental diets were formulated according to standard prescribed by NRC (1994) for white egg laying hens using HWM processed by different techniques *viz.* cooking, autoclaving and extrusion (Table I). Treatment A represented control (without inclusion of HW); while treatment B, C, D represented 4, 8, 12 %, HW processed by cooking, respectively E, F, G represented 4, 8, 12 %, HW processed by autoclaving, respectively and H, I, J represented 4, 8, 12 %, HW processed by extrusion, respectively. The diets were prepared at the start of experiment.

Production data

During the whole experimental period, egg production per experimental group was recorded and at the end of each week total eggs per replicate were calculated. Total eggs laid per replicate were

Table I.- **Composition of experimental diets.**

Ingredients (%)	A	B	C	D	E	F	G	H	I	J
Cooked HW	0	4	8	12	0	0	0	0	0	0
Autoclaved HW	0	0	0	0	4	8	12	0	0	0
Extruded HW	0	0	0	0	0	0	0	4	8	12
Corn	57.06	57.48	52.50	48.10	57.48	52.50	48.10	57.48	52.50	48.10
Soybean meal	26.50	24.66	15.78	10.40	24.66	15.78	10.40	24.66	15.78	10.40
Wheat bran	-	4.34	9.50	16.00	4.34	9.50	16.00	4.34	9.50	16.00
Molasses	4.28	3.50	5.15	5.50	3.50	5.15	5.50	3.50	5.15	5.50
Sunflower oil	1.17	-	-	-	-	-	-	-	-	-
DCP	1.40	1.35	1.30	1.22	1.35	1.30	1.22	1.35	1.30	1.22
Limestone	8.40	7.40	6.40	5.30	7.40	6.40	5.30	7.40	6.40	5.30
Salt	0.10	0.10	0.10	0.12	0.10	0.10	0.12	0.10	0.10	0.12
Premix*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L-Lysine	-	0.09	0.18	0.27	0.09	0.18	0.27	0.09	0.18	0.27
DL-Methionine	0.09	0.085	0.09	0.09	0.085	0.09	0.09	0.085	0.09	0.09

*Premix provided per kilogram of diet: Mn, 140 mg; Cu, 20 mg; Fe, 215 mg; Zn, 125 mg; Se, 0.3 ppm; I, 0.5 mg; vitamin A, 9,000 IU; vitamin D3, 3,000 IU; vitamin E, 30 IU; vitamin K 2.2 mg; riboflavin, 6.5 mg; pantothenate, 17.5 mg; niacin, 95 mg; folic acid, 1.5 mg; vitamin B12, 4 mg/kg

weighed daily and then at the end of each week average egg weight was calculated. The data on egg numbers and average egg weight, thus generated, were used to calculate egg mass/bird/week (weekly egg no. in replicate × average egg weight).

Egg quality traits

Yolk index

Diameter of yolk was recorded with the help of Vernier Caliper while yolk height was measured with the help of a needle provided with a movable loop which was dipped in the center of the yolk, the lower end of the loop was adjusted and the dipped portion of the needle was measured in centimeters. Yolk index was then calculated using yolk diameter and height with the following formula:

$$\text{Yolk index} = \frac{\text{Yolk height}}{\text{Yolk diameter}}$$

Measurement of Haugh unit

It is an expression relating to egg weight and albumen height. Higher Haugh units depict better albumen quality of the egg. Albumen height was determined with the help of a sepherometer. These readings were used to calculate Haugh Unit (HU; Haugh, 1957) value by the following formula:

$$\text{Haugh Unit} = 100 \log [H + 7.57 - 1.7\ W^{0.37}]$$

where H is observed albumen height (mm) and W is weight of the egg (g).

Shell thickness

Shell thickness (mm) was noted using a micrometer screw gauge. Shell membranes were removed manually before the measurements and one reading was taken from end and other from girth of the shell.

Yolk color

Yolk color was determined by comparing yolks with DSM color fan (DSM Nutritional Products Ltd. Switzerland).

Statistical analysis

The data obtained were analyzed by Analyses of Variance (ANOVA) technique under CRD as described by Steel *et al.* (1997). General linear models procedures of SAS software were used to compare treatment effects and alternatively the processing, level and processing level interaction effects on production performance, egg components and egg quality parameters (SAS, 1999). Duncan's Multiple Range Test was used to separate the means (Duncan, 1955).

Table II.- Proximate analysis of raw hatchery waste and meal processed by different techniques

Nutrient* %	Raw hatchery waste	Hatchery waste meal		
		Cooked	Autoclaved	Extruded
Crude Protein	44.63	43.67	45.10	38.64
Crude fat	27.06	27.14	23.75	28.85
Crude fiber	1.05	1.62	1.31	1.47
Total ash	25.88	25.81	26.94	28.90
Nitrogen free extract	1.38	1.76	2.90	2.14
Calcium	17.56	19.02	18.62	18.95
Phosphorus	1.63	1.99	1.44	3.21
Lysine	2.93	2.83	2.80	2.79
Methionine	1.21	1.19	1.19	1.23

*All values are on dry matter basis

RESULTS AND DISCUSSION

Proximate composition

Proximate composition of HW and HWM processed through different techniques is presented in Table II. Highest crude protein (45.1%) was observed in autoclaved HWM with the minimum percentage of crude fat (23.75%), whereas, maximum fat and ash contents (28.90%) were observed in extruded HWM.

Production performance

The effects of feeding HWM on egg production, average egg weight, egg mass and feed conversion ratio are presented in Table III. Comparison of different experimental diets showed that hen day egg production ranged from 69.5 to 79.6 % with highest on the diet containing 4 % HWM processed by autoclaving and lowest (69.4%) on diet having of 12% extruded HWM. But statistically there was non-significant differences between 8 and 12% of autoclaved HWM with cooked meal at all experimental levels. Although hen day production at 8% level was 2.94% less and that of 12% 4.33% less than that of extruded meal included at 4% level but there was statistically non significant differences in all extruded meals but 4% level of extruded meal also revealed non significant differences control, and all types of cooked meal.

Non significant differences were observed in egg weight. Maximum egg production (55.56 g) was observed with extruded meal at 12% level that was similar to control. Minimum was observed with cooked meal included at 4% level (54.33 g) which was only 1.23 g less than grouped showed maximum production but statistically this difference appeared non significant. As regards egg mass, maximum value was observed in group consuming 4% level of autoclaved meal (43.63g/d) which was 5.06g more than group offered 12% extruded meal. In all other experimental units, egg mass differed non-significantly. Same results were observed in feed conversion ratio.

In the current experiment all the eggs laid were weighed and presented a clear picture of average egg weight on daily basis than most of the experiments where eggs are weighed only on the recording day (weekly or fortnightly).

The results of present study are in line with the findings of Kempster (1945) who observed satisfactory growth and feed conversion ratio in White Leghorn chicks when fed dried hatchery waste with 3 and 6% level as a partial dietary substitute for meat scrap or soybean oil meal in an eight week study. Ilian and Salman (1986) in an experiment with broilers, reported increase in body weight gain and feed efficiency of birds fed 2.5 % processed hatchery waste as compared to 0 and 5%. Similarly nutrient dense hatchery by-products were considered equal to or better than a conventional poultry diet with respect to broiler live performance and carcass yield (Deshmukh and Patterson, 1997). However, immediate dehydration or cooking of hatchery waste followed by dehydration to prevent spoilage and the growth of deleterious microorganisms was recommended. In the current

Table III.- Effect of feeding hatchery waste on production parameters.

Treatment[1]		Egg production (%)	Av. egg weight (g)	Egg mass (g/d)	Feed conversion (g/g)
Control		76.55[ab]	54.56	41.76[ab]	2.40
Ck4		74.64[ab]	54.33	40.56[ab]	2.47
Ck8		75.83[ab]	54.57	41.38[ab]	2.42
Ck12		74.06[ab]	54.67	40.48[ab]	2.48
Aut4		79.56[a]	54.84	43.63[a]	2.30
Aut8		72.14[b]	54.42	39.27[ab]	2.58
Aut12		72.24[b]	54.99	39.69[ab]	2.54
Ext4		73.81[ab]	54.48	40.22[ab]	2.50
Ext8		70.87[b]	55.54	39.39[ab]	2.55
Ext12		69.48[b]	55.56	38.58[b]	2.60
Processing of HWM					
Cooking		74.84	54.52	40.81	2.46
Autoclaving		74.65	54.75	40.86	2.47
Extrusion		71.39	55.19	39.40	2.55
Level of HWM					
4 %		76.01	54.55	41.47	2.42
8 %		72.95	54.84	40.01	2.52
12 %		71.93	55.07	39.58	2.54
	SEM	1.022	0.136	0.549	0.036

[a-b] Means within a column with no common superscript differ (P≤0.05)
[1]Control, Basal diet with no hatchery waste; Ck4, Basal diet with 40 g/kg cooked hatchery waste; Ck8, Basal diet with 80 g/kg cooked hatchery waste; Ck12, Basal diet with 120 g/kg cooked hatchery waste; Aut4, Basal diet with 40 g/kg autoclaved hatchery waste; Aut8, Basal diet with 80 g/kg autoclaved hatchery waste; Aut12, Basal diet with 120 g/kg autoclaved hatchery waste; Ext4, Basal diet with 40 g/kg extruded hatchery waste; Ext8, Basal diet with 80 g/kg extruded hatchery waste; Ext12, Basal diet with 120 g/kg extruded hatchery waste.

study, processing of hatchery waste by extrusion proved least effective as far as production performance is concerned. This is contrary to the findings of Deshmukh and Patterson (1997) who demonstrated that extrusion of hatchery waste meal could generate nutrient rich, palatable ingredients that are comparable to traditional ingredients for supporting poultry growth and production. Differences in the composition of raw hatchery waste and storage conditions may explain the disparity between the two studies.

Egg components

Data on the effect of incorporation of HWM in layer diets on egg components are presented in Table IV. Yolk, albumen and shell weights as a percentage of egg weight were not significantly affected with the use of different levels and processing of HWM. Maximum shell weight (12.20%) was noted in group reared on ration formulated with 4% autoclaved meal while minimum was observed in ration consuming meal processed in same manner but included at8% level (11.76%) but this difference was statistically non significant (P>0.5). Same was case with albumen and yolk weight. Albumen weight ranged from 63.53% (autoclaved 4%) to 64.57% (Control). Contrasts among the groups made on the basis of different processing and levels also revealed non-significant effects for egg components. These results revealed that egg components are independent of dietary treatments used in the study. Previous findings of Mazalli *et al*. (2004) supported the findings of current experiment which also showed non-significant differences in the proportion of yolk or albumen to total egg weight.

Egg quality parameters

Table V represents the effect of experimental diets containing varying levels of HWM processed

Table IV.- Effect of feeding hatchery waste on egg components.

Treatment[1]	Shell weight (%)	Yolk weight (%)	Albumen weight (%)
Control	11.89	23.54	64.57
Ck4	12.00	24.44	63.56
Ck8	12.19	24.11	63.70
Ck12	11.98	24.08	63.93
Aut4	12.20	24.27	63.53
Aut8	11.76	24.30	64.15
Aut12	11.79	24.57	64.10
Ext4	12.22	24.29	63.70
Ext8	11.90	24.26	63.88
Ext12	12.00	24.15	63.84
Processing of HWM			
Cooking	12.06	24.21	63.73
Autoclaving	11.92	24.38	63.93
Extrusion	12.04	24.23	63.81
Level of HWM			
4 %	12.14	24.33	63.60
8 %	11.95	24.22	63.91
12 %	11.92	24.26	63.96
SEM	*0.034*	*0.061*	*0.088*

For details of constituents of feed see Table III.

through different techniques on egg quality parameters. Maximum value of albumen height, an indicator of internal egg quality, was obtained after inclusion of 4% autoclaved HWM but it was interesting to note that it decreased when 8% autoclaved HWM was used in the diet. Haugh unit which was derived by using albumen height and egg weight also showed the same trend. The reduction in the internal quality of egg with the decrease in HU was also reported by Senkoylu *et al.* (2005) while using poultry by product meal and feather meal alone or in combination. It was suggested that feather meal or poultry by product meal could be incorporated up to 5% separately or up to 8% in combination in layer diets but with possible detrimental effects on HU.

However, when experimental groups consuming HWM prepared by different processing techniques and levels of HWM with control diet were compared, it showed that albumen height and HU values of eggs obtained by feeding processed Autoclaved 4% HWM were higher (89) than the control diet (85.81). Non-significant differences ($p \leq 0.05$) were observed among the processing techniques. HU was a little bit higher in groups consuming 4 % level than those fed 8 and 12 % of HWM. This was in agreement with the findings of Mazalli *et al*. (2004) who reported non-significant differences for HU estimates of eggs by different treatments while investigating the effect of different fat sources on egg quality.

Shell thickness fell within very narrow range (0.341 to 0.350) and showed non-significant effect of individual dietary treatments on this egg quality parameter. Comparison of processing and levels of HWM also demonstrated no effect. Al Harthi *et al*. (2009) stated that shell quality was improved by addition of this meal in layers diet even added at 8 to 16% level and it also imposed no adverse effects on bird's health. This study supported the finding of Abiola and Onunkwor (2004) who earlier observed that complete replacement of animal protein source like fish meal with HWM in layer diet have no adverse effect on egg quality characteristics. Other egg quality parameters related to yolk, like yolk height, yolk diameter and yolk index were also statistically independent of dietary treatments. Yolk color is usually affected by the change in feed formulation however, the use of different processing and levels of HWM did not ($P>0.05$) effect yolk color. Results are in line with Odunsi *et al*. (2013) who stated that hatchery waste meal can successfully replace fish meal with an enhanced value on egg quality at a reduced cost without any adverse effect on heamatology parameters in laying Japanese quail diets.

CONCLUSION

The findings of this study suggest that autoclaving of hatchery waste is better than extrusion and cooking techniques and 4% of autoclaved HWM may be included in layers ration to get more production than diets with HW. Nevertheless, in layer diets up to 8% HWM could be used to feed the laying hens to maintain reasonably good production without detrimental effects on egg quality.

Table V.- Effect of feeding hatchery waste on egg quality parameters.

Treatment[1]	Albumen height	Haugh unit	Shell thickness	Yolk index	Yolk color
Control	7.30[bc]	85.81[bc]	0.348	0.477	6.71
Ck4	7.36[abc]	86.27[bc]	0.350	0.483	6.58
Ck8	7.68[ab]	88.47[ab]	0.348	0.480	6.76
Ck12	7.64[ab]	88.00[abc]	0.349	0.478	6.70
Aut4	7.81[a]	89.00[a]	0.353	0.486	7.08
Aut8	7.19[c]	85.33[c]	0.344	0.474	6.68
Aut12	7.44[abc]	86.84[abc]	0.341	0.478	6.68
Ext4	7.65[ab]	88.39[ab]	0.348	0.482	6.91
Ext8	7.75[ab]	88.25[ab]	0.341	0.482	6.86
Ext12	7.34[bc]	85.85[bc]	0.343	0.473	6.81
Processing of HWM					
Cooking	7.56	87.58	0.349	0.480	6.68
Autoclaving	7.48	87.06	0.346	0.479	6.81
Extrusion	7.58	87.50	0.344	0.479	6.86
Level of HWM					
4 %	7.60	87.89	0.350	0.484	6.86
8 %	7.54	87.35	0.344	0.479	6.77
12 %	7.47	86.90	0.344	0.476	6.73
SEM	0.045	0.271	0.001	0.001	0.056

[a-c] Means within a column with no common superscript differ (P≤0.05)
For details of constituents of feed, see Table III.

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(Received 21 May 2010, revised 5 May 2015)