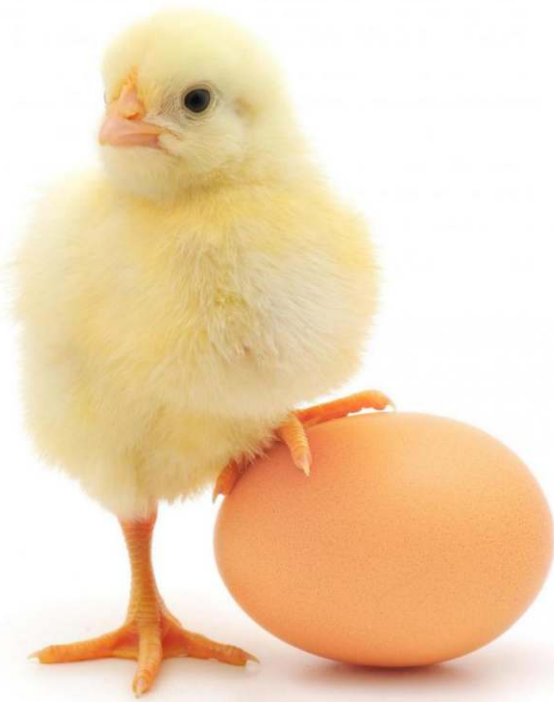
ISSN 1682-8356
ansinet.org/ijps



INTERNATIONAL JOURNAL OF POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

International Journal of Poultry Science 10 (1): 4-7, 2011
ISSN 1682-8356

Duckweed as a Feed Ingredient in Laying Hen Diets and its Effect on Egg Production and Composition

K.E. Anderson[1], Z. Lowman[1], Anne-Marie Stomp[2] and Jay Chang[2]
[1]Department of Poultry Science, North Carolina State University, Box 7608, Raleigh, NC 27695, USA
[2]Department of Bio- and Ag Engineering, North Carolina State University,
Box 7625, Raleigh, NC 27695, USA

Abstract: Duckweed, a prolific aquatic plant, can be used for products including: biofuels (ethanol) and animal feeds. Researchers at North Carolina State University have worked for a decade to develop a system to produce high-protein duckweed biomass utilizing the nutrient-rich effluent from anaerobic digestion of swine wastewater. This aspect of the project was to evaluate a feeding trial utilizing duckweed materials as a protein source in laying hen feed. The nutrient and energy composition of the Duckweed grown in these conditions was determined, then the impact of duckweed in a commercial layer diet on egg production and feed conversion was evaluated. The duckweed samples analyzed contained 29.05% CP, 25.08% C Fiber and 695 kcal/kg AME_n based on a feeding trial with marker. The analysis was used to formulate a layer diet containing 12.6% duckweed. Both the Control (C) and Duckweed (D) diets were formulated to be Iso-nitrogenous (18.1% Crude Protein) and Iso-caloric (2930 kcal/kg). Sixty Hy-Line, w-36 hens were randomly divided into 4 replicates each containing 15 hens from 76-88 wks of age, 2 replicates were placed on the C Diet and the remaining 2 were fed the D diet. Feed consumption and egg production monitored daily and each wk one days collection was analyzed for USDA Grades, haugh unit, shell strength, vitelline membrane strength and yolk color. On wks 3, 7 and 11 whole 6 egg pooled samples were collected and sent in for nutrient composition laboratory analysis. The D diet had no impact on the hen performance over that of the C diet group, 71.1 and 69.5% hen-day production, respectively. There was a significant increase in the percent Grade B eggs in the hens fed the D by 2% over the C hens. Surprisingly, there was no difference in the nutrient composition of the eggs except for Omega 3 levels which were 0.06 % higher ($P<0.0001$) than in the C hens. The results indicate that duckweed can be fed at a 12.6% inclusion rate and not impact the performance of laying hens and may be a means of enhancing Omega 3 levels in eggs.

Key words: Chicken, duckweed, egg quality

INTRODUCTION

Spirodela polyrrhiza is the most geographically distributed species of simple aquatic plants commonly called duckweed. Duckweed species are characterized by extremely rapid growth, simple morphology and high protein content (Landolt and Kandeler, 1987). Although duckweeds can be a nuisance when overgrowing ponds, they have also attracted considerable attention for their ability to capture mineral contaminants from sewage water from sources such as waste from commercial livestock operations or highly irrigated crop production (Landolt and Kandeler, 1987). Their high protein content, ranging from 25-40%, has prompted numerous studies in decades past to determine the feasibility of using duckweed biomass for animal feed (Leng *et al*., 1995; Hanexakowski *et al*., 1995). However low commodity prices, adequate grain and soybean supplies and lack of duckweed agronomic cropping systems at the time these research studies were done all mitigated against further development of duckweed as a crop. Twenty-first Century increased global demand for commodity grains and soybeans for feed, fuel, chemical and polymer production has altered the economic picture for duckweed. Researchers at North Carolina State University have been working for a decade to develop a system to produce high-protein duckweed biomass utilizing the nutrient-rich effluent from anaerobic digestion of swine wastewater. There has also been a renewed interest in identifying value-added products that could be derived from duckweed biomass. Development of genetic engineering methods (Stomp and Rajbhandari, 2000) and recent genome sequencing of S. polyrrhiza [http://www.jgi.doe.gov/sequencing/why/duckweed.html] provide valuable technological resources for genetic modification of the species for value-added products or enhanced wastewater treatment capability.

Corresponding Author: Kenneth E. Anderson, Department of Poultry Science, North Carolina State University, Scott Hall, Rm 237, Box 7608, Raleigh, NC 27695

MATERIALS AND METHODS

A sample of dried duckweed was received into the laboratory for analysis. Prior to its use as a feed ingredient a sample was analyzed for % Dry Matter, Crude Protein, Crude Fat, Crude Fiber, Calcium, Phos and AME_N Kcal/kg. Table 1 shows the complete nutrient analysis for the Duckweed sample.

For this trial we used 60, 74 Week old W-36 Commercial white leghorn hens. The hens were randomly divided into 4 blocks each containing 15 hens. These hens were fed two different diets, the duckweed samples we analyzed contained 29.05% CP, 25.08% C Fiber and 695 kcal/kg AME_n based on feeding trial with marker. The analysis was used to create a layer diet containing 12.6% duckweed. Both the Control (C) and Duckweed (D) diets were formulated to be Iso-nitrogenous (18.5% Crude Protein) and Iso-caloric (2905 kcal/kg) as shown in Table 2.

Each hen was weighed and individually housed in a 13" x 18" x 23.5" Cage with an individual feeder. The hens were placed in the pens two weeks before the trial and allowed to acquaint themselves to their new environment. After two weeks, 2 blocks were placed on the C Diet and the remaining 2 were fed the D diet. The amount of feed was weighed and recorded daily with feeder weigh backs every two weeks. Egg production was recorded daily.

The physical egg quality data was collected each week on a sample of eggs that collected on the second day of each week. The previous 24 h production was used for data collection. The eggs were candled for USDA interior quality and exterior shell quality. USDA Grade Standards as described in CFR Part 56 were applied. The eggs were candled using a high intensity halogen candling light. After the eggs were candled they were taken to the laboratory for Shell strength and elasticity, Haugh Unit score, Vitelline Membrane Strength and Yolk Color. Shell strength was determined by the compression force required to break the shell using a texture analyzer (TA-XT2, Texture Technologies Corp., Scarsdale, NY) set up with an acrylic disk to apply the force to the egg setting small end up in the holding apparatus. Peak force was measured in g and the shell deformation prior to the break (elasticity) was measured in mm. Haugh units were determined using the methods of Haugh (1937). The QCD Haugh unit equipment (Technical Services and Supplies, Chessingham Park, Dunnington, York, England) was used which electronically measured the height of the albumen and calculated the Haugh unit based upon the egg weight.

Every four weeks a second 24 h sample of eggs was collected cracked, pooled, mixed and was sent off to an outside lab for nutrient analysis. The Vitamin E, Beta Carotene, Vitamin A, Cholesterol, Omega-3, Polyunsaturated Fat, Monounsaturated Fat, Total Fat were determined from the pooled samples. Moisture content was determined for each whole egg sample then the dried sample was analyzed for protein percentage using a lico protein analysis system.

Statistical analysis was based upon a completely randomized design. Proc T-test was used to compare the effect of Duckweed vs. Control (No Duckweed).

Table 1: Nutrient analysis of dried duckweed

Nutrient	Unit	Value
Dry matter	%	97.83
Crude protein	%	29.05
Crude fat	%	5.02
Acid detergent fiber	%	25.08
Calcium	%	1.03
Total phosphorus	%	0.64
A.M.E. poultry	Kcal/lb	315.90
Carotene	Mg/lb	61.360
Manganese	PPM	241.00
Iron	PPM	5405.00
Copper	PPM	2.00
Zinc	PPM	167.00

Table 2: Egg production diets for control and duckweed treatment groups

Ingredients	Control (C)	Duckweed (D)
Pounds		
Corn	1180.72	1006.09
Fat, poultry	51.42	139.78
Poultry, by-product meal	146.81	135.02
Soybean meal, dehulled	350.00	225.00
Duckweed		250.00
Wheat bran	50.00	50.00
Calcium Carbonate	176.84	150.02
Di-Calcium Phosphate	26.20	25.58
Salt (NaCl)	5.00	5.00
DL-Methionine	1.00	1.50
Choline Chloride	4.00	4.00
NCSU Trace Mineral Mix	4.00	4.00
NCSU vitamin premix	2.00	2.00
NCSU selenium supplement	2.00	2.00
Total	2000.00	2000.00
Calculated analysis		
Crude protein (%)	18.50	18.50
Crude fat (%)	6.00	10.50
Crude fiber (%)	2.00	4.80
M.E. poultry (kcal/kg)	2904.00	2904.00
Calcium (%)	3.90	3.50
Phosphorus	0.67	0.67

RESULTS

Body weight: The results from Table 3 show the effect of duckweed on the body weight of the laying hens. At the start of the study the control hens were ($p<0.05$) heavier than the hens placed on the Duckweed diet. When the study terminated there was no difference between the two groups of hens. It was shown that the control hens lost more weight than did the Duckweed treatment hens, however these results concluded that duckweed had little impact on the changes of the body weight of a laying hen.

Table 3: Effects of duckweed on laying hens body weight

Diet	Beginning body Wt. (g)	Ending body Wt. (g)	Weight gain/loss (g)
Control	1630*	1598	-31
Duckweed	1547	1534	-14
Pooled SEM	79	53	69

Table 4: Effects of duckweed on a laying hens egg production

Diet	Hen-day production (%)	Eggs per hen (12 wk)	Feed per bird/day (g)	Feed per dozen (kg)
Control	69.5	59	145	2.63
Duckweed	71.1	60	135	2.35
Pooled SEM	3.0	3	7	0.13

Table 4 shows that duckweed at this inclusion level had no effect on a egg production or feed conversion. Feed consumption was high in both groups but appeared to be attributable to feed wastage in both groups.

Table 5 shows the impact of feeding duckweed on the USDA grade. There were no significant effect on the percentage of AA or A grade eggs however there were ($p<0.0001$) greater numbers of Grade B eggs from the birds on the duckweed diet. This points to a shift in egg grades downward with the inclusion of duckweed.

Duckweed's effect on shell and vitelline membrane breaking strength and elasticity are shown in Table 6. From this data it shows that the egg shells from the duckweed diet have a greater elasticity than those eggs from the control hens. This was also the case in with higher vitelline membrane elasticity as well.

Egg weight, percent shell, albumen and yolk component percentages shown in Table 7 indicate that duckweed in the hen's diet had no effect. The only data of significant difference was the color of the yolk, the Rouche color score increased quite significantly from a color of 7 to 11. The protein level in the dried whole egg was not different between the groups. The nutrient composition of the eggs produced by the control and Duckweed fed hens are shown in Table 8. There were no differences between the two diets in Total, Saturated, Mono-Unsaturated or Poly-Unsaturated fats. However, the level of Omega fatty acid was ($p<0.0001$) higher in the duckweed eggs by 0.06%. Cholesterol, Vitamin A, Beta Carotene and Vitamin E were not influenced by the presence of Duckweed in the diet. Cholesterol levels in both dietary groups were much lower than the USDA Nutrient guide of 231 mg/50 g where in this study there was 185.5 and 181.5 mg/50 g of whole egg in the Control and Duckweed Diets, respectively.

Table 5: Effect of duckweed diet on the USDA grades

Diet	Grade AA (%)	Grade A (%)	Grade B (%)	Check (%)	Loss (%)
Control	90	6	0	2.5	3.2
Duckweed	83	12	2****	1.9	2.8
Pooled SEM	6	3	1	2.5	1.8

****(p<0.0001)

Table 6: Effect of duckweed diet on the shell and vitelline membrane breaking strength and elasticity

	Shell		Vitelline membrane	
Diet	Strength (g)	Elasticity (mm)	Strength (g)	Elasticity (mm)
Control	3031	0.44	1.73	4.95
Duckweed	3170	0.48****	1.72	4.99**
Pooled SEM	269	0.02	0.04	0.02

(p<0.01); **(p<0.0001)

Table 7: Effect of duckweed diet on the shell egg weight and component percentages

Diet	Egg weight (g)	Yolk color[1]	Shell (%)	Albumen (%)	Yolk (%)	Protein[2] (%)
Control	64.0	7	7.97	63.44	28.75	47.96
Duckweed	64.5	11***	8.08	63.11	28.77	48.55
Pooled SEM	0.9	1	0.11	0.27	0.12	0.18

[1]Rouch color score 1 (pale yellow) to 14 (red orange). [2]Percentage reported on dry matter basis. ***(p<0.001)

Table 8: Effect of duckweed diet on the nutrient composition analysis in shell eggs

	Total fat	Sat fat	Mono fat	Poly fat	Omega 3	Cholesterol	Vitamin A	Beta carotene	Vitamin E
Source	(%)					(mg/100 g)	(IU/100 g)		
Diet									
Control	9.99	3.33	4.43	1.75	0.09	371.0	631.7	<5	6.10
Duckweed	9.74	3.11	4.19	1.97	0.15****	363.0	714.3	<5	5.60
Pooled SEM	0.12	0.04	0.07	0.03	0.01	14.9	27.3	0	0.36

****(p<0.0001)

DISCUSSION

From these results it can be concluded that the birds fed the duckweed diet had no impact on the hen performance over that of the control diet group, 71.1 and 69.5% hen-day production, respectively. There was, however, a significant increase in the percent Grade B eggs in the hens fed the Duckweed diet by 2% over the control group. This appears to be indicative of a grade shift in the Duckweed fed hens indicating a poorer quality appearance in the eggs. The Rouch Color Score of the duckweed eggs were notably higher. Surprisingly there were no differences in Beta Carotene between the two diets where as in previous studies yolk colors of 11 or higher did result in increased levels of Beta Carotenes. There was no difference in the nutrient composition of the eggs except for Omega 3 levels which were 0.06% higher ($p<0.0001$) than in the C hens. The results indicate that duckweed can be fed at a 12.6% inclusion rate and not impact the performance of laying hens and may be a means of enhancing Omega 3 levels in eggs.

REFERENCES

Hanexakowski, P., B. Szymczyk and M. Wawrzynski, 1995. Composition and nutritive value of sewage-grown duckweed (*Lemna minor L.*) for rats. Anim. Feed Sci. Technol., 52: 339-343.

Haugh, R.R., 1937. The haugh unit for measuring egg quality. U.S. Egg and Poultry Magazine, September, 1937. pp: 552-573.

Landolt, E., R. Kandeler, 1987. Biosystematic investigations in the family of duckweeds *(Lemnaceae)*. Veroff. Geobot. Inst. ETH, Zurich. Vol. 2, pp: 42-43.

Leng, R.A., J.H. Stambolie and R. Bell, 1995. Duckweed- a potential high-protein feed resource for domestic animals and fish. Livestock Res. Rural Dev. (LRRD), 7: 1.

Stomp, A.M. and N. Rajbhandari. 2000 Genetically engineered duckweed. U.S. Patent #6,040, 498.