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Use of Duckweed Growing on Sewage Water as Poultry Feed

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ABSTRACT

Present study was focused on intake of duckweed by chicks and to evaluate the growth performance and carcass characteristics of chicks. A total number of 106 chicks were allocated to 3 treatments with 3 replicates. The treatments were categorized into group A (25% duckweed and 75% commercial feed), group B (50% duckweed and 50% commercial feed) and group C (100% commercial feed). Results showed that crude protein was higher in group B followed by group A while in group C crude protein was lower but total feed intake, average weight, live weight, meat and bone weight, skin weight, head weight, liver weight, intestine weight and shank weight were higher as compared to group A and group B and this was due to the fluffy nature of duckweed and small size of crop. It was concluded that sewage grown duckweed can be successfully utilized as poultry feed. Chicks can survive on duckweed and farmer can save money. This is the first study in Pakistan.

Introduction

Poultry farming has now become one of the most dynamic associated parts of agriculture throughout the world. Poultry culture in South Asian countries is expanding rapidly and the rate of growth of commercial layer and broiler (meat producing) farms is phenomenal to meet the ever increasing demand for proteins through poultry meat and eggs. In Pakistan, poultry industry had made considerable contribution to food production and plays a vital role in the economy of the country. Recently duckweed system was introduced to solve the feed problems of farmer. Duckweed plays an important role in the extraction and accumulation of metals from water (Susarla et al., 2002). Duckweed accumulates excess nutrients into their own biomass (Boyt et al., 1977) and later be processed into a variety of products such as poultry feed and fishmeal thereby bringing a cost recovery aspect into the waste management process (Hillman and Culley, 1978). The duckweeds (Lemna sp., Spirodella sp.) have received the most attention because of their rapid growth to high biomass, ease of handling and high protein content as compared to the other macrophytes.

Numerous studies have demonstrated the value of duckweed as a feed for poultry, fish and other animals (Skillicorn et al., 1993). Duckweed closely resembles to the animal protein and has a better array of essential amino acids than the vegetable protein (Hillman and Culley, 1978). The amino acid profile of duckweed and soybean is very similar (Rusoff et al., 1980) and also has a rich concentration of beta carotene and xanthophylls (Journey et al., 1993). Dried duckweed contains crude protein up to 40% (Vandyke et al., 1977) and can be compared with soybean meal as a source of plant protein. Duckweed was used as feed for poultry because of its high nutritional value (Abdullaev, 1969). Duckweed when dehydrated has been used to replace alfalfa (Lucerne) meal as a protein source in conventional poultry diets as it has high protein content 20-40%, low fiber content, high mineral content, non toxicity and few known pest. The protein content of duckweed responds quickly to the availability of nutrients in the water (Leng et al., 1995). Duckweed has been known for a long period of time as a potential source of food for humans and animals and as a source of natural products it is the only source of supplementary protein for fish, chickens ducks and pigs (Rodriguez et al., 1996). Village pigs, horses or ruminants could be fed on freshly harvested duckweed. For most applications with poultry, dried duckweed would be preferable as it could be expected that duckweed would provide an ideal wet supplement to any high energy diet (Leng et al., 1995). Aim of the current study was to utilize the sewage grown duckweed as feed for poultry for saving the farmers' money.

Materials and Methods

Collection of Duckweed

The duckweed (Lemna minor) was harvested from the wastewater treatment ponds of National Institute of Bioremediation at National Agricultural Research Center (NARC), Islamabad, Pakistan. Purpose was to reclaim the sewage water of main NARC offices building and hostels through bioremediation for irrigation purposes (Fig. 1). The used water treatment garden project was started in October 2008 and finalized in February 2009. Total area was about 0.38 acre. The used water treatment garden facilitated to treat 35,000 US gallons per day for irrigation. The toxicity analysis report of the output water from treatment garden indicated that water was fit for irrigation.

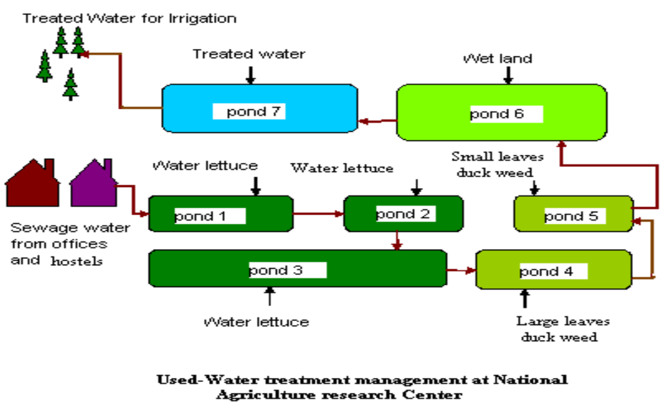

Fig 1. Bioremediation ponds for treatment of sewage water

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After collection of duckweed from pond 4 and 5, the samples were brought in laboratory for analysis and rinsed in distilled water to remove dust and stored in refrigerator for further procedure (freezing and drying). There were two types of duckweed, small leaves duckweed and large leaves duckweed. Duckweed (Lemna minor) was dried in the air for 30 days without sun-drying. Small and large leaves were mixed together and then milled to fine particles after mixed with the commercial feed (standard diet) (table 1) according to the required percentages (Khanum et al., 2005).

In composition of feed, crude protein, dry matter, ether extract, fiber, ash, gross energy, nitrogen free extract (NFE), K, P, Na Ca and afflatoxin were examined and in addition small leaves, large leaves, mixture of small and large leaves and composition of duckweed and commercial feed after mixing were also analyzed (AOAC, 1994).

Chicks rearing and dietary treatment

A total number of 106 chicks were procured from commercial hatchery. Experiment was designed with 3 treatments using 3 replicates each having 11 to13 chicks. These chicks were raised indoors on deep litter system. The chicks were kept up to 4 weeks of age. The experiment was conducted during June, 2010.

In housing, the chicks were provided with 1 square feet space per bird. Lighting schedule was practiced throughout the experiment as well as standard brooding and rearing temperature was maintained.

Fig 2. Housing system of chicks

Water for birds was obtained from a clean source and boiled to eradicate the contaminants. Water was accessible to the birds all the time in the pens as well as vaccination was also provided to the chicks (Table 2).

Statistical analyses

Data regarding weight of bird, weight gain per bird, weight gain per bird per day, feed intake, intake per bird per day and feed conversion ratio was recorded analyzed with Complete Randomized Design (CRD) with two factor factorial analysis of variance by using Minitab software. For significant P-value, least significant difference (LSD) was determined for mean comparison at 5% level.

Results and Discussion

Duckweed closely resembles to the animal protein and has a better array of essential amino acids than the vegetable protein (Hillman et al., 1978). The amino acid profile of duckweed and soybean is very similar (Rusoff et al., 1980) and also has a rich concentration of beta carotene and xanthophylls (Journey et al., 1993). Dried duckweed contains crude protein up to 40% (Vandyke et al., 1977) and can be compared with soybean meal as a source of plant protein. Duckweed was used as feed for poultry because of its high nutritional value (Musaffarov et al., 1968). It has great potential as feed for poultry, and has high moisture content (Leng, 1995). In present study large leaves duckweed has high dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), N and aflatoxin compared to small leaves and mixed leaves duckweed. The ash content was higher in small leaves whereas nitrogen free extract was higher in mixed leaves of duckweed (Table 3).

Duckweed was mixed with the commercial feed categorized into group A, B and C according to composition (Table 3). The dry matter contents of all groups were almost similar. Crude protein was higher (22.67 %) in group B while in group A it was 21.0% but in group C it was very lower (20.65%).

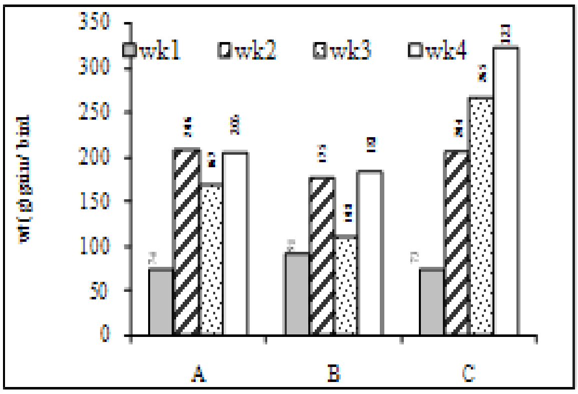

Fig 3a. Average weight per bird in different treatments

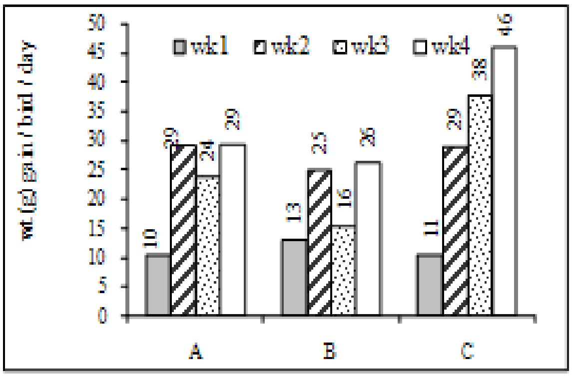

Fig 3b. Average weight gain per bird in different treatments

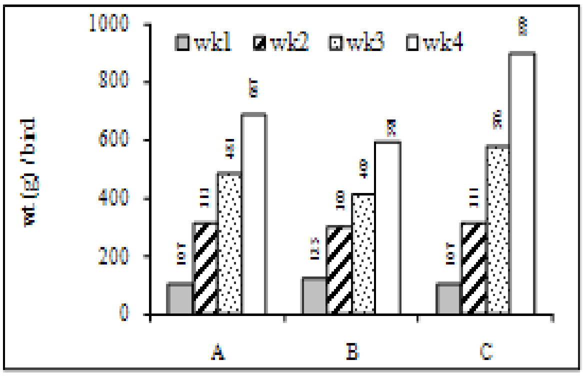

Fig 3c. Average weight gain per bird per day in different treatments

The gross energy was higher in group C (16.175 MJ/kg) and in group A and B it was lower (10.21, 2.5MJ/kg). Crude fiber (5.89%), calcium (1.60%), sodium (17%) and ash (19.55%) were higher in group B whereas nitrogen free extract (61.99%) and ether extract (5.97%) was higher in group C. Gross energy was higher (16.175 MJ/kg) in group C (commercial feed) and low in group B (12.5 MJ/kg) and A (10.2 MJ/kg).

In the beginning of study, the weight of chicks in all treatments was same. During third and 4th week, weight of chicks was higher in group C followed by group A and B (Fig 3a). In case weight gain per bird there was no significant difference in weight during 1st and 2nd week but during week 3rd and 4th week, weight was higher in group C (Fig 3c). In case of average weight gain, the weight was higher in group C (Table 5). Similar studies was conducted by Ngamsaeng et al. (2004) on 24 Muscovy ducks in order to evaluate the protein quality in water spinach (WS) or duckweed (DW) alone or mixed (WS+DW) and they reported average daily gain was highest for ducks fed diet DW (22.4 g/bird/day) and lowest when fed diet WS (6.2 g/bird/day). Khang, (2003) found Chicks fed DW had somewhat higher weight gains (8.3 g/day) compared with chicks fed the diets without DW (7.8 g/day) but no differences were seen in between diets with different CP levels. Khanum et al. (2005) reported the final live weight and average daily body weight gain were significantly lower in the control diet but were not different between duckweed diets. Samnang (1999) found in the station, soyabean supplemented chickens grew faster than duckweed supplemented.

The growth of very young broiler chickens may be retarded with increasing levels of Lemna gibba dehydrated meal in the diet whereas layer hens produced effectively (Haustein et al., 1990a). The growth of chickens fed duckweed, group A and group B was less than the group C which consist of totally commercial feed (P=0.001). It was due to the low intake of chickens fed duckweed. Duckweed was eaten but the amount was less because the birds digestive tract adapts to the type and quantity of food available (Klasing, 1998).

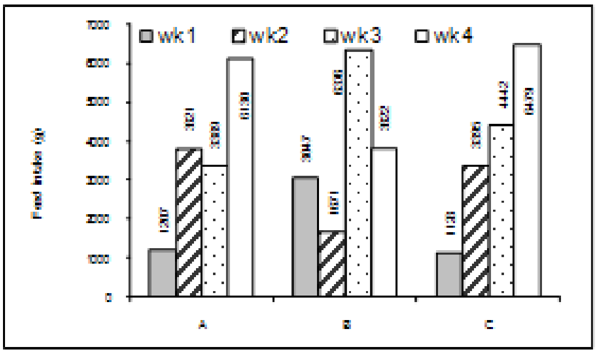

Fig 4a. Feed intake in different treatments

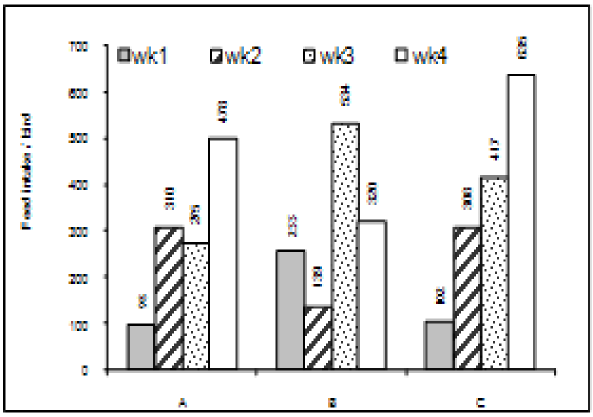

Fig 4b. Feed intake per bird in different treatments

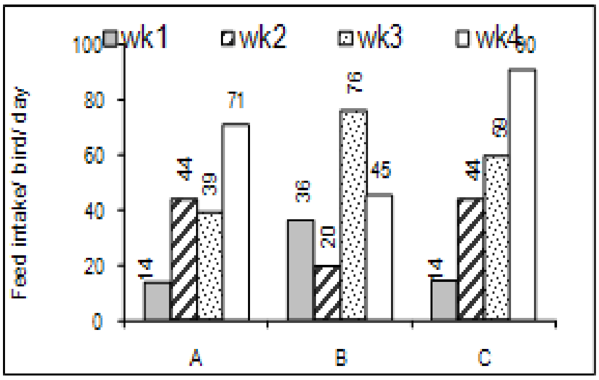

Fig 4c. Feed intake per bird per day in different treatments

During present investigation it was observed that the crop size of chicken fed duckweed was enlarged. This was due to the fluffy nature of duckweed as it absorbs more moisture as a result of which the crop size become enlarge. Duckweed was eaten but the amount was less than reported by Nguyen and Brian, (2004). The birds digestive tract adapts to the type and quantity of food available (Klasing, 1998).

The greater size of crop in birds fed duckweed may be because of higher intake of fiber. As a result of which the group A and group B the chickens has low feed intake and due to this low intake the weight also reduce when compared to the group C which was offered no duckweed. Klasing, (1998) also reported that crop capacity increased on diets high in grass or leaves compared with a diet based on ground grains.

The chickens with access to duckweed tended to have a lower carcass yield than control chickens, probably because of higher contents in the digestive tract as indicated by large size of crop. Mortality rate was very low through out the experiment only two mortality was seen in the group C d and no mortality was observed in group A and group B.

When postmortem of chicks were performed it was observed that these mortalities were not due to any disease but due to a litter which block the respiratory passage and becomes the cause of death (Figure 4abc, Table 5).

Feed Conversion Ratio (FCR) is a measure of a bird's efficiency in converting feed mass into increased body mass. The smaller the FCR the more efficient birds are at converting feed to meat.

FCR of group B was maximum and FCR of group C was minimum. So group C with smaller FCR, the birds were more efficient in converting feed to meat (Fig. 5, Table 5).

Table 1. Ingredients of commercial feed of chicks

Ingredients	Percentage	Ingredients	Percentage
Corn	44.00	Sunflower meal	6.00
Rice	10.00	Marbel chips	0.70
Rice polish	7.00	Dicalcium phos	1.57
Wheat bran	3.90	L-lysine	0.20
C. gluten meal 60%	0.70	Lysine sulphate	0.27
Rapeseed meal	3.00	DL-methionine	0.13
Canola meal	10.30	Sod.Chlorine	0.35
Guar meal	1.00	Threonine	0.08
Soyabean meal	10.30	Phyzyme	0.00
Oil	1.260	Allzyme	0.00
Premix	0.50		

Table 2. Chick's vaccination

Days	Vaccination	Nature
Day-01	IB	Eye-Drop
Day-06	ND	Eye-Drop
Day-10	IBD	Eye-Drop
Day-15	HP	Injection
Day-20	IBD	Eye-Drop
Day-24	ND + IB	Eye-Drop

Table 3. Chemical composition of duckweed leaves

Composition	Small leaves	Large leaves	Mixture of small & large leaves
DM	4.62	6.53	3.77
CP	25.30	29.67	24.01
EE	6.91	7.30	1.37
CF	10.73	11.14	10.21
Ca	3.99	4	4.75
P	1.17	0.94	1.16
N	4.04	4.74	3.84
Na	0.67	0.426	1.8
K	1.205	1.225	4.75
Ash	28.03	19.00	23.69
Nitrogen free extract	32.89	32.89	40.72
Aflatoxin (ppb)	55	76	-
Gross energy (MJ/kg)	12.31	12.89	12.7

Table 4. Composition of duckweed and commercial feed after mixing

Composition	Group A	Group B	Group C
DM	92.41	92.05	92.46
CP	21.0	22.67	20.65
EE	4.54	3.65	5.97
CF	5.57	5.89	4.17
Ca	0.9	1.6	0.4
P	0.82	0.73	0.72
Na	0.12	0.17	0.07
K	0.53	1.23	4.75
Ash	13.18	19.55	7.22
NFE	55.71	48.24	61.99
Gross energy (MJ/kg)	10.2	12.5	16.175

Table 5. Average weight/bird, weight gain per bird, weight gain per bird per day, feed intake, intake per bird per day and feed conversion ratio

	wt/bird	wt gain/bird	wt gain/bird/day	Feed intake	Intake/bird	Intake/bird/day	FCR
A	396	163	23	3637	295	42	1.72
B	356	139	19	3729	311	44	2.2
C	473	216	30	3861	366	52	1.61

Table 6. Mean values for carcass of chicks given duckweed as replacement for commercial feed

Organ weight (g)			
Organs	**Group A**	**Group B**	**Group C**
Live weight	811	777	1013
Meat and Bone	383	318	473
Skin	97	86	141
Head	26	24	32
Liver	23	25	35
Heart	4	6	6
Intestine	74	79	88
Gizzard with feed	32	29	32
Empty gizzard	18	14	17
Shank	33	31	42

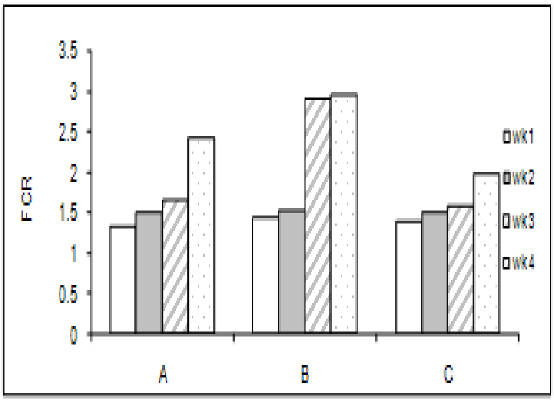

Fig 5. Feed conversion ratio in different treatments and weeks

At the end of the trail one chicken from each of the replicate was slaughter and record the weight of different organs. The chickens with access to duckweed (group A and group B) tended to had lower carcass yield than control chickens (group C), probably because of higher contents in the digestive tract as indicated by large size of crop. As shown in the table 6 the live weight of group C was very high (1013g) as compared to group A (811g) and group B (777g). Meat and bone weight was also high in group C (473g) compared to group A (383g) and group B (318g). Skin weight of group C was increased (141g) as compared to group A (97g) and group B (86g). The weight of other organs such as head, liver, intestine, gizzard with feed, empty gizzard, shank was high in the chicks belong to group C. After group C the weight of organ was high in the chicks belong to group A and weight of organs was less in the chicken belong to group B.

Kabir et al. (2005) found that body weight, feed intake, feed efficiency, protein efficiency, energy efficiency and profitability linearly declined as the proportion of duckweed increased in the diet. Duckweed did not affect on livability ($P>0.05$). The growth of very young broiler chickens may be retarded with increasing levels of Lemna gibba dehydrated meal in the diet whereas layer hens produced effectively (Haustein et al., 1990a). Khanum et al. (2005) found that the final live weight and average daily body weight gain was significantly lower in the control diet but were not different between duckweed diets. Samnang, (1999) found that Soyabean supplemented chickens grew faster than duckweed supplemented. Khang (2003) conducted experiment in order to evaluate the effects of duckweed on the laying performance of local (Tau Vang) hens and concluded that egg production, egg quality, feed conversion and net profit are highest when fresh duckweed replaces 75% of the protein from roasted soya beans in a diet based on broken rice. Even at 100% of roasted soya beans replacement by duckweed, the egg production and margin of income over feed costs were better than on the control diet in which the supplementary protein came only from roasted soya beans.

Conclusion

Sewage grown duckweed can be successfully utilized as poultry feed. The intake and growth rate of chicks offered duckweed was less due to the fluffy nature of duckweed but they survived. Preparation of duckweed does not require extra labor cost for growing and harvesting. It can be produced at house hold level and save farmers money but at commercial level where weight gain is preferred, duckweed does not perform well as chicks do not gain much weight. So the duckweed plant from the wastewater material can be converted into useful product.

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