In the Name of God

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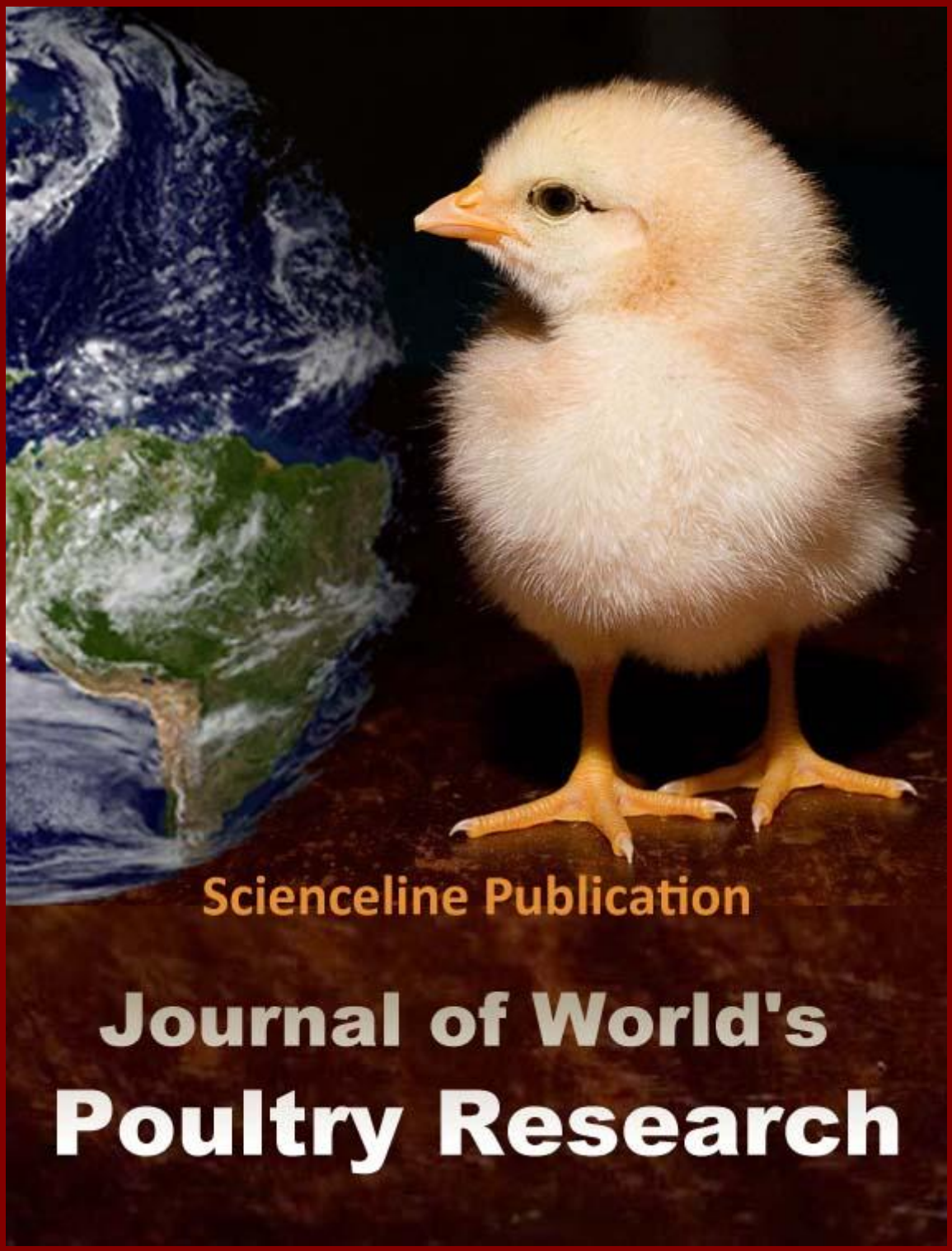

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Volume 6 (1); March 25, 2016

11.6F and 1M: 10.5F. The birds were randomly allotted to 9, 2m x 2m floor pens in an environmentally controlled house. Eggs were collected daily and weekly egg production/bird was calculated for each group. Hatchability and egg production were significantly affected (P < 0.05) by sex ratio. 1M: 1:13.3Fgouphad significantly (P < 0.05) higher egg production. Hatchability of 1M: 10.5F were significantly (P < 0.05) the highest followed by 1M: 11.6F and that of 1M: 13.3F sex ratio were the lowest from week 33.Increasing the sex ratio had the effect that although average egg production/female was lower, but hatchability were improved, possibly as a result of more frequent sexual interactions of males and females.
Key words: Sex ratio, Broiler breeder, Hatchability, Production.

[Full text-PDF] [RICeST] [DOAJ] [AGRIS]

Research Paper

Evaluation of the Nutritive Value and Detection of Contaminants in Feed and Water Samples in Open Poultry Houses of Layer Farms in Gezira State, Sudan.

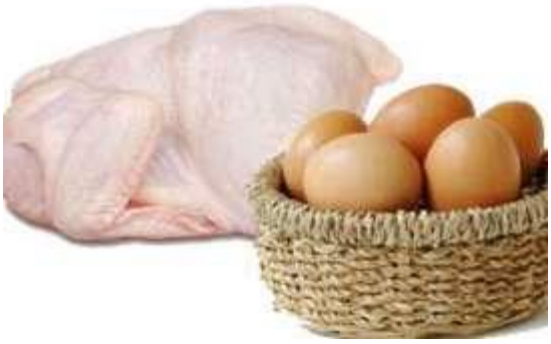
EL-Dikeir N, Mohamed Elbeeli MY, Abdel-Rahim AM, Eshag NA and Mohamed Ali SA.
J. World Poult. Res. 6(1): 18-24; pii: S2322455X1600004-6

ABSTRACT:
This study was carried out in Gezira state, Sudan to investigate feed and drinking water composition and contamination in open layer houses. Data was collected through individual interviews (questionnaires) of 97 randomly selected poultry farm owners during farms visits. Water and feed samples were collected from 20% of the visited farms and data was analyzed using SPSS. Results indicated that feed samples obtained from farms and mills had higher levels of crude protein than recommended; it was about (23-25%) in all localities, which affect birds' kidney that negatively affect egg production. Metabolizable energy was in the recommended range in all localities. There was high fungal growth and aflatoxins presence in feeds in many localities. Total fungal count was from 113 colonies/g in Greater Medani municipality to 2850 colonies/gr in Almanagil municipality and aflatoxins were from 37.5% in Alkamleen to 66.7% in South of the Gezira and Greater Medani localities. Feed ingredients were also contaminated with fungal growth and aflatoxins presence. Drinking water indicated high pH and total hardness in many localities. There was also high bacterial total count in all localities and E-coli was from 5 colonies/ml in Alhasahesa municipality in the north to Greater Medani municipality mto150 colonies/ml in East of the Gezira locality. It was recommended that measures be taken to ensure poultry feed and drinking water safety in addition to adjusting feed composition to nutrients requirements for the specific production to sustain high productivity.
Key words: Poultry feed, Nutritive value, Contaminants

[Full text-PDF] [RICeST] [DOAJ] [AGRIS]

Research Paper

Analysis of Urban Household Demand for Poultry Production in Ado Local Government Area of Ekiti State, Nigeria.



Sekumade AB and Toluwase SW.
J. World Poult. Res. 6(1): 25-30; pii: S2322455X1600005-6

ABSTRACT:
The study investigates the urban household demand for poultry products in Ado Local Government areas of Ekiti State, Nigeria. A two-stage sampling technique was used to select respondents for the study. Ten wards were randomly selected in Ado local government area and this was followed by a random selection of twelve households from each selected ward, making a total number of 120 respondents used for the survey with the aid of structured questionnaires. The analytical techniques used include descriptive statistics like mean, minimum value, maximum value; standard deviation and linear regression analysis were used to analyze the relationship between the household's socio-economic characteristics and the amount spent on poultry products. The results obtained revealed that majority of the household (45.4) percent believed that taste of the poultry product determine the demand for poultry products, the mean amount spent on poultry product monthly is ₦4,918.61(24.59USD) which is very low, it may be due to the high price of poultry products or easy accessibility to a close substitute which made respondents demand for more substitutes than poultry products and the regression analysis for the determinant of households demand for poultry products reveals that variables such as "years spent in formal education, household size and average monthly income" had positive effect on amount spent on poultry products. There should be a policy measure that will ensure increase in purchasing power of the people's income which will invariably contribute positively to the improvement of nutritional status of the people and government price intervention program should be introduced in order to stabilize the fluctuation of poultry products prices.
Key words: Analysis, Urban, Household, Demand, Poultry Products

[Full text-PDF] [RICeST] [DOAJ] [AGRIS]

Review

A Review on Effects of Probiotic Supplementation in Poultry Performance and Cholesterol Levels of Egg and Meat.

Getachew T.

J. World Poult. Res. 6(1): 31-36; pii: S2322455X1600006-6

ABSTRACT:
Probiotics are live microbial food/feed ingredients that have a beneficial effect on health that stimulates the growth of beneficial microorganisms and reduces the amount of pathogens, thus improving the intestinal microbial balance of the host and lowering the risk of gastro-intestinal diseases. Probiotics can be harmful to debilitated and immuno-compromised populations. An accurate dosage of administration has yet to be established despite the wide-use of probiotics. Probiotics have antimutagenic, anticarcinogenic, hypocholesterolemic, antihypertensive, anti-osteoporosis, and immunomodulatory effects. *Lactobacillus*, *Bifidobacterium, Leuconostoc, Enterococcus, Lactococcus, Bacillus, Saccharomyces, Aspergillus* and *Pediococcus* species are most commonly used probiotics in poultry production. When supplemented to chicken probiotics improve feed-intake, growth performance, meat quality, egg production, egg quality and have cholesterol lowering potential in poultry products. However, some studies reported no significant effect of probiotics on feed-intake, production traits, products' quality and cholesterol level.
Key words: Broiler, Feed intake, Hypocholesterolemic, Layer, Probiotic

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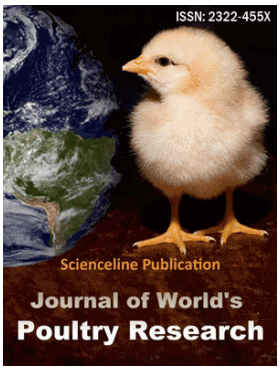
The Journal of World's Poultry Research



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Research Paper
PII: S2322455X1500001-5

Effects of Feeding Dietary Palm Kernel Cake on Egg Production and Egg Quality of Khaki Campbell Duck

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ABSTRACT

The study examined the effects of graded levels of Palm Kernel Cake (PKC) on the laying performance and egg quality in Khaki Campbell ducks. Twenty-seven female Khaki Campbell ducks were randomly assigned to three dietary treatments viz T1 (0% PKC; control), T2 (15% PKC) and T3 (35% PKC) and the performance characteristics and egg quality traits were examined for 4 weeks. Ducks fed T2 and T3 had higher ($P<0.05$) intake than the T1 birds. Nonetheless, diet had no effect ($P>0.05$) on the feed conversion ratio in ducks. Similarly, dietary PKC did not affect ($P>0.05$) the weekly egg production and the percentage of hen-day production. Ducks fed T2 and T3 had greater ($P<0.05$) egg weight compared with T1. The egg haugh unit, shell thickness and yolk color were not affected ($P>0.05$) by dietary PKC. Results indicated that Khaki Campbell ducks could tolerate up to 35% PKC in their diets without detrimental effects on egg production and egg quality.

Key words: Palm Kernel cake**,** Intake, Egg quality, Egg production

INTRODUCTION

Egg is a good source of high quality proteins, vitamins and minerals, hence it is one of the important components of a healthy human diet (ENC, 2012). In addition, eggs are inexpensive and easy to prepare compared with other sources of animal protein (ENC, 2012). Global egg production has increased dramatically over the last 20 years with Asia taking the lead (FAO, 2014). In order to meet the incessant demand for a cheap source of high quality animal protein such as egg, production cost must be reduced to the bare minimum. It has been accentuated that feed accounts for about 70% of the total cost of production of livestock (Zanu et al., 2012). The competition between human and livestock for conventional feedstuffs has led to the scarcity and increased in the price of these feedstuffs (Afolabi et al., 2012). In order to maintain productivity at a lower cost, it is thus imperative to incorporate cheaper and readily available alternative feedstuffs in livestock diets.

Malaysia is the world's largest producer of palm oil with more than 5 million hactares of land devoted to oil palm plantation. Palm Kernel Cake (PKC) is an important by-product of the palm oil industry and is obtained after the extraction of palm kernel oil from the kernels of the oil palm fruits (Alimon, 2004). PKC is classified as energy feed stuff and its chemical composition is somewhat similar to copra meal, rice bran or corn gluten feed (Yoeng et al., 1981). Thus, PKC has been used to spare conventional feed ingredients such as maize, rice bran and soybeans in animal diets due to its consistent availability and competitive price (Onuh et al., 2010). In Malaysia, the price of PKC was Malaysian Ringgit MYR650 per tonne whereas the price of corn and wheat is MYR1080 and MYR2230 per tonne respectively (DVS, 2013). PKC is widely used as a moderate source of protein and energy in different livestock such as swine (Adesehinwa, 2007), rabbit (Orunmuyi et al., 2006), laying hens (Afolabi et al., 2012 and Chong et al., 2008) and broiler chickens (Sharmila et al., 2014). In poultry, the level of PKC supplementation is varies. For instance, Yeong et al. (1981) suggested that the optimum inclusion rate of PKC is 15% for broiler chickens and higher levels diminished the growth performance and efficiency. However, Onuh et al. (2010) reported a significant reduction in the body weight and feed intake of finisher broiler chickens only when the inclusion rate of PKC exceeds 30%. Given the discrepancies among studies on the efficacy of PKC, it is difficult to rely on such information especially when utilizing PKC in different livestock species such as Khaki Campbell duck. There is meager information on the effects of PKC on production and egg quality traits in Khaki Campbell ducks. Thus, the objective of the

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current study was to determine the effects of feeding different levels of PKC on the growth changes, egg production and egg quality of Khaki Campbell ducks.

MATERIAL AND METHODS

Twenty seven female Khaki Campbell ducks of 18 weeks of age with an average body weight of 1.25 kg to 1.40 kg were used in the study. Ducks were randomly assigned into 9 different pens. Each pen contained three ducks. The pens were randomly assigned to three experimental diets; T1: basal diet (control), T2: basal diet + 25 % PKC, and T3: basal diet + 35 % PKC. Dietary treatments were formulated to meet the nutrient requirement of laying ducks based on the recommendation of National Research Council (Table 1). The proximate composition of the feed samples was analyzed according to the procedure of AOAC (1990).

Birds were fed twice a day at 7.30 am and 4.30 pm. Upon the arrival of the ducks till the end of week 4, commercial diet was given to all treatment groups. Starting from week 5 to the end of week 6 the commercial diet was gradually reduced and replaced with the experimental diet. Data were collected from week 7 until week 10. Feed intake, body weight changes and feed conversion ratio, weekly egg production and the hen-day egg production were documented. The eggs were collected twice a day at 8.00 am and at 5.00 pm were stored in a refrigerator at 20℃ until egg analysis.

Analysis of the egg weight, haugh unit and yolk color were done using the egg analyzer machine. For egg shell thickness, egg shell was left on the egg tray to dry for one day. The next day, the inner shell membrane was removed and a vernier caliper was used to measure the top and bottom thickness of the shell.

Table 1. Nutrient composition of the experimental diets

Ingredients (%)	T1 (control)	T2 (PKC15)	T3 (PKC35)
Corn	65.66	53.44	36.92
PKC	-	15.00	35.00
Soybean meal	20.16	17.86	15.90
Fish meal	3.00	3.00	3.00
Wheat pollard	7.00	4.30	0.40
Palm oil	1.00	3.20	6.50
Salt	0.25	0.25	0.25
Vitamin	0.05	0.05	0.05
Minerals	0.05	0.05	0.05
Dicalcium phosphate	2.70	2.70	2.70
Limestone	0.60	0.60	0.60
DL-Methionine	0.04	0.05	0.06
L-lysine	0.04	0.05	0.07
Calculated ME, kcal/kg	2913.9	2914.6	2928.2

PKC15, basal diet containing 15% PKC; PKC35, basal diet containing 35% PKC; ME, metabolisable energy

Table 2. Chemical composition of the experimental diets

Ingredients (%)	T1 (control)	T2 (PKC15)	T3 (PKC35)
DM (%)	88.31	90.67	92.51
CP (%)	15.00	15.00	15.00
EE (%)	3.74	5.65	7.29
CF (%)	2.67	4.31	6.84

PKC15, basal diet containing 15% PKC; PKC35, basal diet containing 35% PKC; DM, dry matter; CP, crude protein, EE, ether extract, CF, crude fiber

Statistical analysis

The experiment followed a completely randomized design. Data were subjected to the GLM procedure of SAS. Differences between treatment means were compared using Dunnett's test.

RESULTS AND DISCUSSION

The chemical composition of the feedstuffs and experimental diets are presented in Tables 1 and 2 respectively. Supplementation of PKC increased the dry matter, ether extract and crude fibre content of the diets. Nonetheless, the diets were isocaloric and isonitrogenous.

The effect of dietary PKC on body weight changes in Khaki Campbell ducks is shown in Figure 1. Regardless of the diet, the initial weight of the ducks was higher than the final weight. However, the decrease in weight was only significant for ducks fed 0 and 15% PKC. The decrease in body weight during the laying period could be due to the mobilization of body nutrient reserves for egg production. The lower body weight

changes observed in birds fed 35% PKC diet compared to those fed 0 and 15% PKC could be due to the increase in dietary fat as dietary PKC increased in diet. Dietary fat is an efficient source of energy for livestock (Zulkifli et al., 2007).

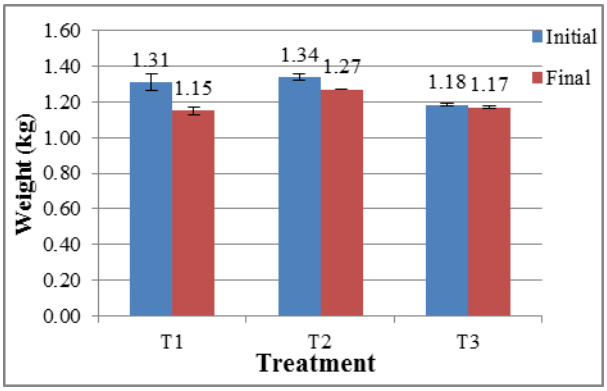

Figure 1. Growth changes of the Khaki Campbell duck after 10 weeks of experimentation.

Birds fed 15% and 35% PKC had higher (P<0.05) feed intake compared with those fed the control diet (Table 3). This observation could be attributed to the need to compensate for the lower digestibility of PKC. PKC is a fibrous feed known to have low viscosity, low water holding capacity and high bulk density (Onwudike, 1986). These features make PKC to have a high rate of passage in the digestive tract. In addition, the nutrients in fibrous feeds such as PKC would not be readily released because such nutrients are diluted with the fibre content (Onwudike, 1986). Thus, birds need to adjust their feed intake in order to obtain the nutrients and energy required for optimal production performance (Afolabi et al., 2012). Birds eat to satisfy their energy requirements (Leeson et al., 2001).

Nonetheless, since the dietary treatments were isocalaric, it can be ruled out that the ducks eat more PKC based diets to meet their energy requirements. There is a possibility that the ducks eat to satisfy their high demand of amino acid requirements for egg production. This assertion corroborates the findings of earlier studies wherein voluntary feed intake in broilers increased when dietary protein content was reduced from 24% to 16% (Edmonds et al., 1985 and Parsons et al., 1984). Onwudike (1986) posited that the high fiber content in PKC led to less availability of amino acids needed for egg production in birds. The higher feed intake in ducks fed PKC diets could also be attributed to the palm oil added to the diets. Dietary fats promote feed palatability and stimulate metabolizable energy and feed intakes in birds (Zulkifli et al., 2007). The higher feed intake observed in ducks fed PKC-based diets was in agree with the findings of Chong et al. (2008) who observed that laying hens fed 12.5% and 25% PKC had higher feed intake and lower feed efficiency compared with those fed the control diet.

Table 3. Feed Consumption and Feed Conversion Ratio of the Khaki Campbell duck after 10 weeks of experimentation

Treatment	Weekly Feed Intake(g)	Feed Conversion Ratio
T1	1021.20 ± 70.89	6.25 ± 0.67
T2	1425.31 ± 71.66 ***	5.12 ± 0.24
T3	1337.94 ± 91.29 ***	5.53 ± 0.50
Pr	NS	NS

NS: Not significantly different (P>0.05), ***significantly different at 5% level (P<0.05); Pr: probability, T1: control diet, T2: 15% PKC, T3: 35% PKC

Table 4. Egg production and percent duck-day production of the Khaki Campbell duck after 10 weeks of experimentation

Treatment	Weekly Egg Production(g)	% hen-day production
T1	4.202 ± 0.447	60.019 ± 6.386
T2	4.230 ± 0.411	60.417 ± 5.880
T3	5.397 ± 0.512	77.083 ± 7.324
P value	NS	NS

NS: Not significantly different (P>0.05), T1: control diet, T2: 15% PKC, T3: 35% PKC

Table 5. Egg weight, egg haugh unit, egg shell thickness, egg yolk color of the Khaki Campbell duck after 10 weeks of experimentation

Treatment	Egg Weight (g)	Egg Haugh Unit	Egg Shell Thickness (mm)	Egg Yolk Color
T1	59.52 ± 1.01	41.57 ± 2.24	0.30 ± 0.004	5.70 ± 0.20
T2	65.75 ± 0.79***	35.21 ± 1.77	0.31 ± 0.01	5.22 ± 0.20
T3	63.24 ± 0.55***	38.34 ± 2.36	0.30 ± 0.01	5.93 ± 0.27
P value	***	NS	NS	NS

NS: Not significantly different (P>0.05), ***significantly different at 5% level (P<0.05). T1: control diet, T2: 15% PKC, T3: 35% PKC

Dietary PKC had no effect (P>0.05) on the FCR (Table 3). These finding contrasts with those of Chong et al. (2008) who observed that birds fed 12.5% and 25% PKC had lower FCR compared with those fed the control diet. In addition, Afolabi et al. (2012) observed that Nigerian indigenous laying birds fed 20 to 40% PKC had lower FCR compared to those fed control diet. The authors also observed that birds fed 50% PKC diet had poorer FCR compared to the control (P<0.05).

Egg production and the hen-day production percentage were not influenced (P>0.05) by dietary PKC (Table 4). The findings are in line with those of Chong et al. (2008) who observed that laying hens fed 12.5% or 25% PKC were able to maintain their production performances. Onwudike (1988) posited that PKC could be used up to 40% in layers' diet without detrimental effect on production performance. The authors observed a reduction in egg production and feed intake when more than 40% PKC was supplemented. Perez et al. (2000) observed reduced egg production when 50% PKC was supplemented. Afolabi et al. (2012) also observed that layers fed 50% PKC had the least hen-day production when compared to those fed 0, 10, 20, 30 and 40% PKC.

Dietary PKC improved (P<0.05) the egg mass but did not affect (P>0.05) the haugh unit, shell thickness and yolk color (Table 5). Ducks fed 15% and 35% PKC had higher egg mass compared with those fed the control diet (P<0.05). The impact of dietary PKC on egg quality traits had yielded conflicting results. Akpodiete (2008) observed that when fed dietary PKC up to 40% did not affect the internal and external qualities of the egg. Afolabi et al. (2012) demonstrated that albumin level was higher in eggs from layers fed the control and 10% PKC diets. The authors also observed that the yolk color score increased significantly as the level of PKC increased but the egg weight and egg shell thickness were similar across the diets. Chong et al. (2008) observed that layers fed the control and 12.5% PKC diets had higher egg weight compared to those fed 25% PKC. The authors also observed that the color of egg yolk became paler as dietary PKC increased in diet.

CONCLUSION

The results of the present study demonstrated that Khaki Campbell ducks can tolerate up to 35% PKC in their diet without deleterious effect on laying performance and egg quality characteristics.

Competing interests

The authors have no competing interests to declare.

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Research Paper
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Effect of Beeswax, Gelatin and *Aloe vera* Gel Coatings on Physical Properties and Shelf Life of Chicken Eggs Stored at 30°C

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Received: 19 Feb. 2016
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ABSTRACT

Present study was to determine the effect of beeswax, gelatin and *Aloe vera* gel coatings on internal quality and shelf life of chicken eggs compared to uncoated and mineral oil coated eggs. Four hundred and seventy five brown shell eggs were obtained from 32 weeks old Lohmann classic brown layers and all the eggs were randomly divided into five groups as ninety five eggs per group. Mineral oil, beeswax, *Aloe vera* gel and gelatin coatings were applied on eggs as four treatments and one group of eggs were uncoated and kept as control group. Then all the eggs were stored at 30°C and relative humidity of 70% - 75% for six weeks of storage period. Beeswax and gelatin coated eggs showed significantly ($P<0.05$) lower weight loss values and preserved albumin and yolk quality of eggs than uncoated eggs. Eggs coated with mineral oil and beeswax showed similar results for weight loss, Haugh unit, yolk index, albumen and yolk pH. Based on the Haugh Unit, eggs can be classified into four grades as AA (above 72), A (72-60), B (59-31) and C (below 30). Quality of uncoated eggs, *Aloe vera* coated eggs and gelatin coated eggs dropped from AA to B and mineral oil and beeswax coated eggs changed from initial AA quality to A quality after six weeks of storage at 30°C. Results of microbiological analysis showed that all coated eggs were microbiologically safe throughout the storage period. The present study demonstrated that, in comparison to the mineral oil and the uncoated eggs, beeswax is a better novel coating material and gelatin can also be successfully used as coating material in preserving the internal quality and extending the shelf life of chicken eggs stored at 30 °C for six weeks.

Key words: Chicken eggs, Coatings, Internal quality, Shelf life, Storage time

INTRODUCTION

As an excellent source of protein, chicken eggs are among the most nutritious food consumed globally and their production has represented an important segment of the world food industry (Farrel, 2013). However, shell eggs are highly susceptible to internal quality deterioration and bacterial growth during storage. As soon as eggs are laid, the aging process begins, altering their chemical, physical, microbial and functional properties. Although the shell can be considered as natural barrier, shell eggs have short shelf life and are extremely fragile which can cause a serious economic loss to the poultry industry (Caner, 2005 and Wong et al, 1996).

Interior quality deterioration of fresh shell eggs can be delayed significantly by maintaining storage temperature near the freezing point (Zeidler, 2002). Numerous food grade coating materials have also proven to be efficient in reducing the mass transfer by sealing pores. Furthermore, such surface coatings prevent the penetration of microorganisms into the shell eggs. Thus Considerable amount of research works have been done on coating shell eggs with edible coating materials and different results in terms of efficacy of prolonging the shelf-life and improving internal qualities of eggs were obtained depending on type of the coating material (Ikame and Enelamah, 1985).

Antimicrobial-enhanced coatings, which are considered as active packaging, have been receiving increased interest since they exhibit great potential for ensuring food safety. Beeswax is a product of honey bees with natural antimicrobial substances (Zanoschiet al., 1991). Thus, it has considerable antibacterial and antifungal effect on bacteria, fungi and yeasts (Kacániová et al., 2012). Due to these anti-microbial and barrier properties against moisture and gases, beeswax has been utilized in food processing as packaging and coating material. In addition, *Aloe vera* (*A. vera*) is a tropical and sub-tropical plant having well proven its anti-microbial properties. The colorless and odorless gel obtained from *A. vera* leaves can form protective layer against oxygen and moisture and

inhibit the action of microorganisms that cause food borne illness (Serrano et al., 2006). Thus studies have shown that *A. vera* gel can be effectively used as surface coating to preserve fruits and vegetables.

Gelatin is obtained by controlled hydrolysis of fibrous insoluble protein collagen, which is widely found as a major component of the skin, bone and the connective tissues of animals. It is used to encapsulate the moisture or oil phase in food ingredients and pharmaceuticals. Due to barrier properties of gelatin it has been gained increased interest as novel surface coating material (Gennadios et al., 1994).

Mineral oil is a coating material currently used to preserve the internal quality of eggs (Waimaleongora-Ek et al., 2009 and Jirangrat et al., 2010). Even so, a problem associated with mineral oil coating is that oil dries very slowly when applied on the surface of the eggshell without wiping. However, none of the previous studies provided detailed information on internal quality and shelf life of stored chicken eggs after applying above mentioned coatings. Therefore, this study was carried out to evaluate the effectiveness of beeswax, gelatin and *Aloe vera* gel as novel coating materials in compared to mineral oil, to preserve the internal quality and shelf life of chicken eggs stored for six weeks at 30°C.

MATERIAL AND METHODS

Selection of eggs

475 brown shell eggs were obtained from 32 weeks old Lohmann classic brown layers at local producer (NEL Farm, Mangalaeliya, Sri Lanka). All the layers in the farm had been vaccinated for salmonella at chick stage so eggs were free of vertically transmitted *salmonella* spp. The eggs were obtained from battery cages therefore had lesser dirt. Furthermore, eggs were cleaned by wiping with piece of steel wool to clean any possible dirt on shell. All the selected eggs were less than six hours after laying and in the weight range of 49g- 64g. In addition eggs were unfertile, free of cracks and defects. Eggs were placed in clean egg creates at 30°C temperature after been brought to laboratory and all the eggs were randomly divided into five groups with 95 egg in each group.

Preparation of coating materials

Before preparation of coating solutions and while coating was done surgical gloves were worn to avoid any possible contaminations. In addition, 10 eggs per each group were weighted with analytical balance (AR0640, OHAUS, USA) before coating and two hours after coating to measure the mean weight of coat for single eggs for each coating material.

Preparation of Mineral oil

Mineral oil (viscosity 26.35 mPa s at 20°C, weight per ml at 25°C = 0.828 g, light absorption at 240-280 nm = 0.031, transparent, colorless, odorless, food grade) was obtained from Glorchem Enterprise (No 141, Bankshall Street, Colombo 11, Sri Lanka). For coating process, .mineral oil was put into250 ml beaker and eggs were immersed individually in mineral oil solutions by hand for one minute.

Preparation of beeswax and coating of eggs

Crude beeswax was purchased from local shop and solid beeswax was cut into small pieces by knife and put in to a clean 500 ml beaker which was set in a boiling water bathe at 40°C. Then beeswax was heated until it became a liquid and cooled up to room temperature to form semi solid beeswax that can be easily applied on to egg shell. Eggs were subsequently coated with beeswax by rubbing wax on the shell with hand.

Preparation of *Aloe vera* gel and coating of eggs

Fresh *A. vera* leaves were taken from the *A. vera* plants grown in Wayamba University, Makandura premises, Sri Lanka. Then outer cover of the *A. vera* leaves was scraped by clean knife and thin layer of gel was directly applied on egg shell.

Preparation of gelatin and coating of eggs

10% Gelatin solution was prepared by dissolving commercial gelatin powder with distilled water and heated in a water bathe (80°C) for 10 minutes to get dissolved gelatin solution. Well dissolved gelatin solution was cooled in room temperature before coating. Then gelatin solution was put into 250ml clean beaker and eggs were immersed individually by hand in the gelatin solution for one minute.

Storage of coated eggs

After coating all the coated eggs were dried at room temperature for 24 hours. Uncoated eggs served as control and mineral oil coated eggs served as positive control. Then all the eggs were subsequently placed in small end down position in labeled open molded plastic eggs trays and stored at 30°C and relative humidity of 70% - 75% for six weeks period. Twenty five eggs, as five individually marked eggs per each treatment were kept for measuring weight loss throughout the experimental period. Using three replicates per treatment Haugh unit, yolk index, albumin pH, yolk pH, were measured 24 hours after coating (0 week) and in weekly intervals for six weeks storage period. For microbial analysis, six eggs (three for total plate count and three for *Salmonella* spp. and *E. coli* detection) per each treatment were taken 24 hours after coating and then in two weeks intervals during six weeks storage period.

Determination of quality parameters of coated eggs

Determination of weight loss: Weight loss (%) of the coated whole eggs during storage were calculated as ((initial whole egg weight (g) after coating at day 0 – whole egg weight (g) after storage)/initial whole egg weight (g) after coating at day 0) × 100. Weight loss (%) of the control uncoated whole egg was calculated as ((initial whole egg weight (g) at day 0 – whole egg weight (g) after storage)/ initial whole egg weight (g) at day 0) × 100. The weight of whole eggs was measured with analytical balance (AR0640, OHAUS, USA) and

five measurements per treatment were taken in each week.

Determination of Haugh Unit and Yolk Index: Eggs were broken into flat surface and height of thick albumen and yolk were measured with tripod meter. The yolk width was measured with a digital caliper. Each parameter was estimated by averaging three measurements carried out at three different points of albumen and yolk. The Haugh unit was calculated as 100 log (H – $1.7W^{0.37}$ + 7.57), where H is the albumen height (mm) and W is the weight (g) of egg (Haugh, 1937). The yolk index was calculated as yolk height/yolk width (Stadelman, 1995a and Lee et al., 1996). Three replicates per treatment were taken at each week.

Determination of albumin pH and yolk pH: Albumen and yolk were separated in to 50 ml beakers and thin and thick albumen were mixed thoroughly. Then albumen pH and yolk pH were measured with pre calibrated digital pH meter (Starter 3000, OHAUS, USA) at 25°C. Three replicates per treatment were taken at each week.

Microbial analysis

Internal content of control uncoated eggs and coated eggs were analyzed for Total Plate Count (TPC), *Salmonella* spp. and *E .coli* since day one up to six weeks in two weeks intervals. TPC was done at microbiology laboratory, department of food science and technology, Wayamba university of Sri Lanka. For TPC, egg shell was sterilized with 70% ethyl alcohol before breaking the eggs. Then internal content of the egg was put into a sterilized 50 ml beaker and homogenized with sterilized glass rod. Oneml of homogenized egg sample was diluted with peptone water to prepare 10^{-1}dilute sample. Thus, Dilution series were prepared up to 10^{-3} level. Then viable cells (Colony forming units/ml of eggs) were enumerated by colony counter on plate count agar by pour plate method followed by incubation at 37°C for 48 hours.

Tests for *Salmonella* spp. and *E .coli* were done at poultry disease diagnostic laboratory, district veterinary investigation center, Wariyapola, Sri Lanka. Sample of internal egg content was taken with sterilized cotton swab by making crack on egg shell and cultured in a nutrient blood agar followed by 48 hours incubation. If microbial growth was noticed, sub culture was plated on MacConkey broth, Brilliant Green agar, Salmonella-Shigella (SS) agar, Xylose Lysine Desoxycholate (XLD) agar, Triple Sugar Iron (TSI) SI agar and Citrate media to detect the presence of *Salmonella* spp. and *E. coli*. All microbiological assays were done in duplicate for each treatment.

Statistical analysis

For Haugh unit, yolk index, albumin pH, yolk pH mean ± standard deviation values were reported based on three replicates per treatment. For weight loss, mean ± standard deviation values were reported based on five replicates per treatment. Data were analyzed using general linear model procedure considering the main effects of coating, storage time at 95% confidence level. When main effect was significant, the Tukey's comparison test was performed to identify significant differences within treatments in a particular week and differences within storage period in a particular treatment. Minitab statistical software (version15.1.1, USA) was used for analysis.

RESULTS AND DISCUSSION

Effect of beeswax, *Aloe vera* gel and gelatin coatings on weight loss

Evaporation of water and, to a much lesser extent, loss of Carbon dioxide (CO_2) from the albumen through the shell leads to overall weight loss of the whole egg (Obanu and Mpieri, 1984). This is one of the important measurements to monitor the changes in quality of fresh shell eggs during storage.

During six weeks of storage period at 30°C, differences in the weight loss among the control uncoated eggs and those coated with mineral oil, beeswax, *A. vera* gel and gelatin were found ($P<0.05$). Overall, the weight loss progressively increased with increased storage periods (Table 1). But eggs coated with mineral oil and beeswax had significantly ($P<0.05$) lesser weight loss than uncoated, *A. vera* gel, and gelatin coated eggs throughout the six weeks of storage period. However, there were no significant differences ($P>0.05$) in weight loss observed among uncoated, *A.vera* and gelatin coated eggs throughout six weeks of storage. Similarly there were no significant difference ($P>0.05$) in weight loss between mineral oil and beeswax coated eggs. After six weeks, nearly five times lesser weight losses in mineral oil (1.49%) and beeswax (1.52%) were observed than uncoated eggs (7.49%). Weight loss of *A. vera*gel (6.81%) and gelatin (6.26%) coated eggs were slightly lower than that of uncoated eggs (7.49%) but more than four times higher than mineral oil and beeswax coated eggs (1.49% - 1.52%) (Table 1).

Waimaleongora-Ek et al. (2009) reported that, at 25 °C storage, the weight loss (0.85%) of eggs coated with mineral oil after five weeks was lower than that (1.97%) of uncoated eggs after one week. Moreover, Obanu and Mpieri (1984) reported that, vegetable oil coatings significantly reduced (11 times less) the weight loss (0.013-0.016 g) of coated eggs, compared to that (0.186 g) of uncoated eggs after 35 days of storage at 25-32 °C. However it was obvious that *A. vera* gel and gelatin coatings were less effective in minimizing weight loss than mineral oil and beeswax (Table 1).

According to Food and Agriculture Organization (2003), a weight loss of 2-3% is common in marketing eggs and is hardly noticeable to consumers. This study demonstrated that beeswax similar to mineral oil ($P>0.05$) offer a protective barrier against the loss of moisture through the eggshell, thus minimizing weight loss (< 1.52%, Table 1).

Effect of beeswax, *Aloe vera* gel and gelatin coatings on Haugh unit

During storage of shell eggs, the gelatinous structure of the thick albumen gradually deteriorates, changing into thin albumen (thinning), which is

associated with either ovomucin-lysozyme interactions, disulfide bonds of ovomucin, carbohydrate moieties of ovomucin, or interrelations between α and β ovomucins (Li-Chan and Nakais, 1989). The Haugh unit, an expression relating egg weight and height of the thick albumen, is a measurement of the albumen quality. The higher the Haugh unit value, the better the albumen quality of eggs. Significant changes in the Haugh unit ($P< 0.05$) of all treatment groups during 6 week of storage at 30°C were observed (Table 2). Generally, the Haugh unit gradually decreased with increased storage periods; however, this decrease progressed at a much slower rate for eggs coated with beeswax, gelatin and mineral oil than for *A. vera* gel coated and uncoated eggs. Compared with uncoated and *A. vera* gel coated eggs, eggs coated with beeswax, gelatin and mineral oil had significantly higher Haugh units ($P<0.05$) throughout six weeks of storage at 30°C.

At the beginning of the experiment (0 week) all the eggs were having Haugh unit between 86.55 – 86.74 and after six weeks storage, it had dropped to 41.03, 49.72, 62.41, 57.13 and 61.31 in uncoated, *A. vera* gel, beeswax, gelatin and mineral oil coated eggs respectively (Table 2). These results were substantiated by previous observations for mineral oil coated eggs (Waimaleongora-Eket al., 2009 and Jirangratet al., 2010). Based on the Haugh unit, eggs can be classified into four grades: AA (above 72), A (72-60), B (59-31), and C (below 30) (Lee et al., 1996). At 30°C, the grade of uncoated, *A. vera* gel and gelatin coated eggs decreased rapidly from an initial AA to B grade after six weeks of storage (Table 2). However, eggs coated with beeswax and mineral oil, (which was in AA grade at beginning) had maintained A grade after six weeks of storage period. These results revealed that, beeswax was better in preserving albumen quality during six weeks of storage period, which was similar to the mineral oil.

Effect of beeswax, *Aloe vera* gel and gelatin coatings on yolk index

During storage of shell eggs, the yolk index value (an indicator of freshness) declines as a result of a progressive weakening of the vitelline membrane, reduction of the total solid and liquefaction of the yolk caused mainly by the osmotic diffusion of water from the albumen (Obanu and Mpieri, 1984 and Stadelman, 1995a). In present study, the yolk index values of uncoated and coated eggs decreased significantly ($P<0.05$) with increased storage periods (Table 3). But decrease progressed in a higher rate in uncoated and *A. vera* gel coated eggs than beeswax, gelatin and mineral oil coated eggs. As indicated in table 3, at the beginning of the study all the eggs had yolk index of 0.43 – 0.45. Although yolk index values dropped to 0.25 and 0.24 in uncoated and *A.vera* gel coated eggs after two weeks, other coated eggs with beeswax, gelatin and mineral oil maintained 0.40, 0.36 and 0.39 respectively. After six weeks of storage period, uncoated (0.14) and *A. vera* gel coated (0.15) eggs had significantly lower yolk index values ($P<0.05$) than that of beeswax (0.35), gelatin (0.26) and mineral oil (0.33) coated eggs. Yolk index values of beeswax, gelatin and mineral oil at sixth week were even higher than the yolk index values of control group and *A. vera* gel coated eggs at second week.

These results indicated that, beeswax coating has enhancement effect in maintaining yolk quality similar to the mineral oil during storage. Moreover, both beeswax and gelatin minimized yolk quality loss, as they effectively reduced the rate of water and Carbon dioxide (CO_2) loss from the albumen through the egg shell, thereby inhibiting albumen liquefaction and water uptake by the yolk. Similarly Caner (2005) and Obanu and Mpieri (1984) had noticed significant differences in yolk index of eggs coated with groundnut, cottonseed and coconut oils after 36 days of storage under ambient conditions.

According to Torrico et al. (2011), Haugh unit, weight loss and yolk index are highly correlated. In this study, Table 1 (weight loss), Table 2 (Haugh unit) and Table 3 (yolk index) collectively imply that coating with beeswax and gelatin can preserve both albumen and yolk quality for at least three more weeks compared with observed for uncoated eggs at 30 °C.

Effect of beeswax, *Aloe vera* gel and gelatin coatings on albumen pH

The albumen pH can also be used as an indicator of the albumen quality of eggs (Scott and Silversides, 2000). Freshly laid eggs contain 1.44-2.05 mg CO_2/g of albumen (Keener et al., 2001) and have an albumen pH value of 7.6-8.7 (Waimaleongora-Eket al., 2009). During storage, carbon dioxide escapes via eggshell pores, resulting in thinning of the thick albumen and an increased albumen pH value up to 9.6-9.7 (Li-Chan and Nakai, 1989)

In the beginning of the study, all the eggs were in 8.91 – 8.97 pH range and since then, pH of the uncoated and *A. vera* gel coated eggs were significantly ($P<0.05$) increased than beeswax, gelatin and mineral coated eggs during six weeks of storage period. This implies that beeswax, gelatin and mineral oil as coating materials could retard loss of Carbon dioxide (CO_2) through eggshell pores by acting as a gas barrier (Obanu and Mpieri, 1984 and Stadelman, 1995b). There were no significant differences ($P>0.05$) in albumen pH among uncoated and *A. vera* gel coated eggs and neither were among beeswax and mineral oil coated eggs during six weeks of storage at 30°C (Table 4).

The pattern for changes in albumen pH during the storage periods differed between five treatment groups. The albumen pH of uncoated and *A. vera* gel coated eggs increased from 8.93-8.95 to 10.21 and 10.26 respectively after six weeks of storage. However, the opposite was observed for eggs coated with beeswax, gelatin and mineral oil. Whereas, the pH gradually decreased from 8.93-8.97 to 8.48, 8.62 and 8.29 after five weeks and thereafter slightly increased to 8.40, 9.47 and 8.80 respectively after six weeks of storage at 25 °C (Table 4). Similarly, Jirangrat et al. (2010) observed that the albumen pH of uncoated eggs markedly ($P<0.05$) increased from 8.71 to 9.42 while, that of mineral oil coated eggs slightly decreased (but not significant, $P>0.05$) from 8.71 to 8.64 after five weeks of storage at 25°C.

The decrease in albumen pH during storage may be due to the continuing breakdown of the constituents in egg white and/or a change in the bicarbonate buffer system (Obanu and Mpieri, 1984; Biladeau and Keener, 2009). However, differences in initial egg quality, egg size, and storage conditions (temperature, humidity, and period) may affect albumen pH before and after storage (Goodwin et al., 1962; Sabrani and Payne, 1978). These results implies that beeswax had better barrier properties similar to mineral oil to avoid CO_2 loss via shell pores and which lower the albumen pH incensement during long storage, similarly gelatin was also better in avoid CO_2 loss compared uncoated eggs.

Table 1. Weight loss (g) of control and coated eggs during six weeks of storage at 30°C.

Coating	Day 1	Week 2	Week 3	Week 4	Week 5	Week 6
Control	$1.47\pm0.24^{A,a}$	$2.58\pm0.43^{B,a}$	$3.80\pm0.65^{C,a}$	$5.04\pm0.87^{D,a}$	$6.23\pm1.07^{D,a}$	$7.49\pm2.18^{E,a}$
Aloe vera gel	$1.36\pm0.04^{A,a}$	$2.40\pm0.11^{B,a}$	$3.48\pm0.14^{C,a}$	$4.59\pm0.19^{D,a}$	$5.68\pm0.25^{E,a}$	$6.81\pm0.31^{F,a}$
Beeswax	$0.31\pm0.06^{A,b}$	$0.53\pm 0.12^{AB,b}$	$0.77\pm0.19^{ABC,b}$	$1.02\pm 0.27^{BCD,b}$	$1.27\pm0.36^{CD,b}$	$1.52\pm0.43^{D,b}$
Gelatin	$1.32\pm0.17^{A,a}$	$2.27\pm0.21^{B,a}$	$3.29\pm0.31^{C,a}$	$4.29\pm0.41^{D,a}$	$5.27\pm0.51^{E,a}$	$6.26\pm0.62^{F,a}$
Mineral oil	$0.34\pm0.14^{A,b}$	$0.82\pm0.25^{AB,b}$	$0.84\pm0.43^{AB,b}$	$1.07\pm0.56^{AB,b}$	$1.29\pm 0.66^{AB,b}$	$1.49\pm0.76^{B,b}$

Means ± standard deviations of 3 measurements. $^{A-D}$ Means with different superscripts within a row indicate significant differences ($P<0.05$). $^{a-c}$ Means with different superscripts within a column indicate significant differences ($P<0.05$).

Table 2. Haugh unit of control and coated eggs during 6 weeks of storage at 30°C.

Coating	Day 1	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Control	$86.55\pm2.58^{A,a}$	$70.27\pm4.67A^{B,a}$	$57.62\pm4.64^{BC,a}$	$51.31\pm3.30^{BC,a}$	$49.29\pm3.85^{C,a}$	$47.56\pm3.30^{C,a}$	$41.03\pm3.60^{C,a}$
Aloe vera gel	$86.71\pm2.37^{A,a}$	$65.67\pm2.01^{AB,ab}$	$53.47\pm3.19^{B,a}$	$52.12\pm2.97^{B,a}$	$51.57\pm3.46^{B,ab}$	$50.72\pm4.13^{B,a}$	$49.72\pm3.95^{B,ab}$
Bees wax	$86.72\pm1.17^{A,a}$	$79.43\pm3.23^{AB,a}$	$71.59\pm2.44^{AB,b}$	$67.19\pm4.58^{AB,b}$	$66.10\pm5.56^{AB,b}$	$63.69\pm5.62^{AB,b}$	$62.41\pm4.25^{B,c}$
Gelatin	$86.74\pm2.80^{A,a}$	$72.08\pm4.65^{AB,ab}$	$68.13\pm2.46^{AB,b}$	$65.83\pm2.55^{B,b}$	$64.87\pm4.95^{B,b}$	$62.66\pm2.48^{B,b}$	$57.13\pm4.52^{B,bc}$
Mineral oil	$86.62\pm1.19^{A,a}$	$74.07\pm4.60^{AB,ab}$	$68.78\pm3.91^{AB,b}$	$64.17\pm3.72^{B,b}$	$63.22\pm3.55^{B,b}$	$62.02\pm2.81^{B,b}$	$61.31\pm2.94^{B,c}$

Means ± standard deviations of 3 measurements. $^{A-D}$ Means with different superscripts within a row indicate significant differences ($P<0.05$). $^{a-c}$ Means with different superscripts within a column indicate significant differences ($P<0.05$).

Table 3. Yolk index of control and coated eggs during 6 weeks of storage at 30°C.

Coating	Day 1	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Control	$0.43\pm0.01^{A,a}$	$0.32\pm0.01^{B,a}$	$0.25\pm0.02^{C,a}$	$0.18\pm0.02^{BC,a}$	$0.16\pm0.01^{D,a}$	$0.15\pm0.01^{D,a}$	$0.14\pm0.01^{D,a}$
A. vera gel	$0.44\pm0.01^{A,a}$	$0.30\pm0.01^{B,a}$	$0.24\pm0.03^{C,a}$	$0.18\pm0.02^{D,a}$	$0.17\pm0.02^{D,a}$	$0.15\pm0.01^{D,a}$	$0.15\pm0.00^{D,a}$
Bees wax	$0.44\pm0.01^{A,a}$	$0.42\pm0.01^{AB,b}$	$0.40\pm0.01^{AB,b}$	$0.39\pm0.03^{AB,b}$	$0.37\pm0.03^{AB,b}$	$0.36\pm0.03^{B,b}$	$0.35\pm0.03^{B,b}$
Gelatin	$0.45\pm0.00^{A,a}$	$0.41\pm0.01^{AB,b}$	$0.36\pm0.02^{BC,b}$	$0.34\pm0.02^{CD,b}$	$0.29\pm0.02^{DE,c}$	$0.27\pm0.02^{E,c}$	$0.26\pm0.03^{E,c}$
Mineral. Oil	$0.43\pm0.01^{A,a}$	$0.43\pm0.02^{A,b}$	$0.39\pm0.02^{AB,b}$	$0.38\pm0.03^{AB,b}$	$0.29\pm0.02^{AB,b}$	$0.34\pm0.01^{B,b}$	$0.33\pm0.02^{B,b}$

Means ± standard deviations of 3 measurements. $^{A-D}$ Means with different superscripts within a row indicate significant differences ($P<0.05$). $^{a-c}$ Means with different superscripts within a column indicate significant differences ($P<0.05$).

Table 1. Albumen pH of control and coated eggs during 6 weeks of storage at 30°C.

Coating	Day 1	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Control	$8.95\pm0.24^{A,a}$	$9.18\pm0.14^{A,a}$	$9.25\pm0.19^{A,a}$	$9.20\pm0.04^{A,a}$	$9.30\pm0.08^{A,a}$	$9.95\pm0.48^{B,a}$	$10.21\pm0.16^{B,a}$
A.vera gel	$8.91\pm0.20^{A,a}$	$8.98\pm0.50^{A,a}$	$9.26\pm0.20^{AB,a}$	$9.15\pm0.05^{AB,a}$	$9.07\pm0.15^{AB,ab}$	$9.87\pm0.42^{BC,ab}$	$10.26\pm0.07^{C,a}$
Bees wax	$8.97\pm0.29^{A,a}$	$8.14\pm0.08^{B,bc}$	$7.95\pm0.07^{B,bc}$	$7.74\pm0.19^{B,b}$	$8.48\pm0.36^{ABC,bc}$	$8.48\pm0.01^{ABC,c}$	$8.40\pm0.02^{BC,b}$
Gelatin	$8.92\pm0.07^{A,a}$	$8.45\pm0.45^{A,ac}$	$8.70\pm0.03^{A,bd}$	$8.48\pm0.30^{A,c}$	$8.62\pm0.21^{A,abc}$	$8.98\pm0.18^{AB,bc}$	$9.47\pm0.19^{B,c}$
Mineral Oil	$8.93\pm0.07^{A,a}$	$7.88\pm0.08^{A,bc}$	$7.87\pm0.07^{A,bcd}$	$7.76\pm0.21^{A,b}$	$8.29\pm0.46^{B,ac}$	$8.54\pm0.36^{AB,c}$	$8.90\pm0.51^{AB,bc}$

Means ± standard deviations of 3 measurements.$^{A-D}$ Means with different superscripts within a row indicate significant differences ($P<0.05$). $^{a-c}$ Means with different superscripts within a column indicate significant differences ($P<0.05$).

Effect of beeswax, *Aloe vera* gel and gelatin coatings on yolk pH

At day 1 no significant difference in yolk pH between treatments was noticed, hence all the eggs were having yolk pH in the range of 6.33- 6.37 (Table 5). During 6 weeks of storage period yolk pH was slightly increased from the initial value in all uncoated and coated eggs. Increase of pH was significantly higher ($P<0.05$) in uncoated eggs than that of coated eggs until week 2 and controversy, there was no significant difference in yolk pH ($P>0.05$) of all treatments at week 3.During storage, pH of the albumen increases due to Carbon dioxide (CO_2) loss and water from the albumen migrate into the yolk, leading to increased pH of the yolk as well (Biladeau and Keener, 2009). After six weeks of storage initial yolk pH value of uncoated (6.36), *A. vera* gel (6.37), beeswax(6.37), gelatin (6.33) and mineral oil (6.34) were increased to

7.64, 7.50, 7.46, 7.17 and 7.59 respectively (Table 5), whereas ultimate pH value of gelatin coated eggs was significantly lower ($P < 0.05$) than that of uncoated and other coated eggs.

Microbiological analysis

Results of Total Plate Count (TPC) and detection of *Salmonella* spp. and *E. coli* for internal content of uncoated and coated eggs with beeswax, gelatin and mineral oil during the storage period are shown in table 6 and table 7 respectively. Up to two weeks storage period, no TPC was detected in all uncoated and coated eggs. After four weeks, TPC of 2.5 log CFU/ml and 2.2 log CFU/ml were detected in uncoated eggs and gelatin coated eggs respectively. Ultimately after six weeks of storage period, TPC of 3.2 log CFU/ml, 2.1 log CFU/ml and 2.6 log CFU/ml were detected in uncoated, *A. vera* gel and gelatin coated eggs respectively, whereas no TPC was detected in beeswax and mineral oil coated eggs. As shown in table 7, no *salmonella* spp. was detected in all uncoated and coated eggs during six weeks of storage period at 30°C. In addition *E. coli* was not detected in all uncoated and coated eggs up to two weeks of storage period but *E. coli* colonies were detected in uncoated and gelatin coated eggs after four weeks of storage. After six weeks of storage eggs *E. coli* colonies were detected in all uncoated and other coated eggs except beeswax. This may be due to antimicrobial properties of the beeswax.

According to Ricke et al. (2001), eggs products should meet the specification of less than 5.0×10^4 CFU/g for TPC and absence of *Salmonella* spp. The International Commission on Microbiological Specification of Foods (1986) has mentioned microbiological safety parameters for eggs as absence *Salmonella* spp. and $1.0\text{-}5.0 \times 10^4$ CFU/ g for TPC value. According to these standards, present results (Table 6 and 7) indicated that all uncoated and coated eggs were microbiologically safe throughout the six weeks of storage period at 30°C.

Table 5. Yolk pH of uncoated and coated eggs during 6 weeks of storage at 30°C.

Coating	Day 1	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Control	$6.36\pm0.19^{A,a}$	$7.43\pm0.40^{B,a}$	$7.43\pm0.41^{C,a}$	$6.54\pm0.37^{A,a}$	$6.82\pm0.20^{ABC,a}$	$7.66\pm0.25^{BC,a}$	$7.64\pm0.16^{BC,a}$
Aloe vera gel	$6.37\pm0.30^{A,a}$	$6.84\pm0.31^{AB,ab}$	$6.48\pm0.38^{AB,b}$	$6.57\pm0.18^{ABC,a}$	$7.54\pm0.22^{B,b}$	$7.66\pm0.42^{B,a}$	$7.50\pm0.42^{B,a}$
Bees wax	$6.37\pm0.12^{A,a}$	$6.72\pm0.31^{AB,ab}$	$6.66\pm0.34^{ABC,b}$	$6.32\pm0.19^{ABCD,a}$	$7.68\pm 0.06^{BCD,a}$	$7.19\pm0.19^{BCD,a}$	$7.46\pm0.35^{D,a}$
Gelatin	$6.33\pm0.07^{A,a}$	$6.55\pm0.29^{AB,b}$	$6.39\pm0.14^{ABC,b}$	$6.56\pm0.35^{ABCD,a}$	$6.64\pm0.26^{ABCDE,ac}$	$7.07\pm0.17^{BDE,a}$	$7.17\pm0.30^{BDE,a}$
Mineral oil	$6.34\pm0.12^{A,a}$	$6.73\pm0.10^{B,ab}$	$6.19\pm0.08^{C,b}$	$6.59\pm0.25^{ABCD,a}$	$6.76\pm 0.08^{BD,ac}$	$7.29\pm0.23^{E,a}$	$7.59\pm0.26^{E,a}$

Means ± standard deviations of 3 measurements. $^{A-D}$ Means with different superscripts within a row indicate significant differences ($P<0.05$). $^{a-c}$ Means with different superscripts within a column indicate significant differences ($P<0.05$).

Table 6. Total plate count of uncoated and coated eggs in 2 weeks intervals from first day to six weeks of storage period at 30°C.

Treatment	Day 1 log CFU/ml	Week 2 log CFU/ml	Week 4 log CFU/ml	Week 6 log CFU/ml
Control	Not detected	Not detected	2.5	3.2
Aloe vera gel	Not detected	Not detected	Not detected	2.1
Beeswax	Not detected	Not detected	Not detected	Not detected
Gelatin	Not detected	Not detected	2.2	2.6
Mineral oil	Not detected	Not detected	Not detected	Not detected

Table 7. Detection of *Salmonella* spp. and *E. coli* in uncoated and coated eggs within 2 weeks intervals from first day to six weeks of storage period at 30°C.

Treatment	***Salmonella* spp.**				***E. coli***			
	Day 1	**Wk 2**	**Wk 4**	**Wk 6**	**Day 1**	**Wk 2**	**Wk 4**	**Wk 6**
Mineral oil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Positive
Aloe vera gel	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Positive
Beeswax	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Gelatin	Nil	Nil	Nil	Nil	Nil	Nil	Positive	Positive
Control	Nil	Nil	Nil	Nil	Nil	Nil	Positive	Positive

Nil: Negative for *Salmonella* spp. and *E. coli*

CONCLUSION

Coating was effective in preserving internal quality and improving shelf life of chicken eggs for six week of storage period. All coated eggs except *A. vera* gel showed better results in weight loss, Haugh unit, yolk index and pH compared to uncoated eggs. During six week storage period, highest weight loss (7.49%) was observed in uncoated eggs, whereas beeswax showed the lower weight loss (1.52%) next to mineral oil (1.49%). Thus beeswax coated eggs had lower moisture and CO_2 loss by effective sealing of pores in egg shell. Beeswax coated eggs as same as with mineral oil coated eggs maintained "A" quality during entire

storage period compared to B quality in uncoated, *A. vera* gel and gelatin coated eggs. Whilst uncoated eggs showed lower yolk index values after six weeks of storage, higher yolk index values were observed in beeswax and gelatin coated eggs. Although, there were no significant differences (P>0.05) in yolk pH value among treatments, beeswax and gelatin coated eggs had low albumen pH than uncoated and *A. vera* gel coated eggs. Results of microbiological analysis showed that, all coated eggs were microbiologically safe throughout the six weeks of storage period of at 30°C. Beeswax was desirable coating material to increase the shelf life and preserve internal quality of chicken eggs. Moreover, good consumer acceptability could also be achieved in beeswax coated eggs by adopting proper egg coating methods. Gelatin was with high potential to use as egg coating material and it is essential to study different concentrations of gelatin solutions to achieve best internal quality preservation and improved shelf life.

Competing interests

The authors have no competing interests to declare.

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Effect of Sex Ratio on the Production and Hatchability of Broiler Breeder Flock

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ABSTRACT

Trials to compare mating ratios are important for optimizing the breeding efficiency of broilerbreeder flocks.The study provides information on the reproductive performance of broiler breeder flock (Ross308) maintained at different male: female (M: F) ratios. 381, thirty week-old broiler breeders were randomly divided into three experimental groups with three replicates each and were assigned to one of the following male: female ratio, 1M: 13.3F, 1M: 11.6F and 1M: 10.5F. The birds were randomly allotted to 9, 2m x 2m floor pens in an environmentally controlled house. Eggs were collected daily and weekly egg production/bird was calculated for each group. Hatchability and egg production were significantly affected ($P<0.05$) by sex ratio. 1M: 13.3Fgrouphad significantly ($P<0.05$) higher egg production. Hatchability of 1M: 10.5F were significantly ($P<0.05$) the highest followed by 1M: 11.6Fand that of 1M: 13.3F sex ratio were the lowest from week 33.Increasing the sex ratio had the effect that although average egg production/female was lower, but hatchability were improved, possibly as a result of more frequent sexual interactions of males and females.

Key words: Sex ratio, Broiler breeder, Hatchability, Production.

INTRODUCTION

Several factors have been reported to affect the fertility and the hatchability of chicken eggs. In breeding flocks of birds, mating ratio of male to females plays a pivotal role in optimizing fertility and hatchability in the eggs produced by a flock (Altan and Oguz, 1993). Management at the breeder farm as well as at the hatchery should be adjusted according to the strains, because every strain responded differently to hatchability.

For commercial broiler breeder flocks, Breedersgenerally recommend around 8 to 9 males per100 females at 20 to 30 weeks of age with areduction to 6 to 7 males by the end of thelaying period (the Cobb Breeding Company, 1997; Ross Breeders Ltd., 1998 and Hubbard Farms Inc., 1996). At greater than 10 malesper 100 females, fertility may be adversely affectedby excessive male aggression and competition for mating and territory (Hubbard Farms Inc., 1996; Newcombe, 1996 and Kiers, 1997). Althoughratios as low as 7 males per 100 femalescan give adequate fertility in older flocks (The Cobb Breeding Company, 1997; Ross Breeders Ltd., 1998 and Hubbard Farms Inc., 1996), there is a danger which in some conditions,there may be insufficient males to impregnatean acceptable number of females.

There is a hypothesis that fluctuating selection driven by sex ratio dynamics contributes to describe the maintenance of genetic variation in personality traits, so, any change in the ratio exhibits a marked effect onhatchability and fertility of eggs (Newcombe, 1996; Kiers, 1997 and Giudicw, 2012).

Males to females ratio in a poultry flock is a major factor in clarifyingthe behavior in animals. Too few or too many males in a unit place may be cause a higher percent of infertile eggs. Female to male ratios for havingbest results inhatchability and fertility varies from species to species.However Wilson and Holland (1974) indicated there was no significant difference between mating ratios of 1 male to2 females and 1 male to 3 females in quails particularly on hatchability andfertility of incubated eggs as well as on hatchability of fertile eggs.

So, the aim of this experiment was to investigate different effects of sex ration production and hatchability of broiler breeder flock (Ross308).

MATRIAL AND METHODS

Experimental design

351Females (F) and thirty Males (M), 30 weeks-old broiler breeder (Ross308) were obtained and housed in pens of identical size in a deep litter system with wood shaving floor.

The birds were randomly divided into three experimental groups with three replicates each and

were assigned to one of the following cock to hen ratio: 1M:13.3F, 1M: 11.6F and 1M: 10.5F.

The trial lasted for 10 weeks. All birds were fed a standard commercial diet based on corn and soybean meal. The diet was offered to the birds daily at 09:00, whereas water was given *ad libitum* to all the birds. The composition of diets is shown in Table 1.Strict sanitation practices were maintained in the house before and during the course of experiment. The cages were daily cleaned to prevent any disease outbreak. Vaccination and medication were applied when required during the experimental period.

Table 1. The experimental basal diets composition and calculated proximate analysis (kg)

Diet composition	Female(Kg)	Male(Kg)
Corn	668	727
Soybean meal	218	140
wheat bran	10	85
Soybean oil	6	-
Limestone carbonate	68	18
Dicalcium phosphate	16	15
Mineral premix	3	3
Vitamin premix	3	3
Salt (NaCl)	3	3
DL-methionine	1	0.5
L-lysine	0.5	0.1
Choline chloride	2	2
Vitamin D	0.5	0.5
Vitamin E	0.5	2.4
Vitamin K_3	0.5	0.5

Egg production was recorded daily. Weekly egg production/bird was also calculated for each group. Eggs were stored (maximum 6 days) in a store room at 15^{o}C withmean 78% relative humidity, till setting in an incubator. At the end of incubation period(waiting for five days since the appearance of first hatched egg) non-hatched eggs were separated andbroken to inspect for late embryonic mortality, if any.

Data analysis

The data were analyzed statistically through ANOVA and the means were compared by Least Significant Difference Test by using the General Linear Model of Minitab Micro Computer Software (SPSS 11.5 for windows). Differences were considered significant at P<0.05.

RESULTS AND DISCUSSION

Table 2 shows the effects of different sexual ratios on egg production. As it is shown in table 2,male to female sex ratios in all ages do not exhibit a significant (P<0.05) effect on egg production. But the higher number of eggs was produced by the group 1 at mating sex ratio 1:13.3. This means that increasing the sex ratio did not increase egg production. The results of the present study are in line with the findings of Karousa et al. (2015) who reported that quails housed with a mating ratio of1male to 3females produced more eggs than quails housed with mating ratio1male to 2 females but this difference was non-significant. The obtained results revealed that there were no significant differences (P>0.05) in the total egg production due to sex ratio. These results agreed with Al-Rawi (1980) who found that presence of males had no significant effect on egg production.

Table 2. Influence of male to female sex ratios on egg production of broiler breeders (Ross 308)

Groups	Age (week)										
	30	31	32	33	34	35	36	37	38	39	40
1	85.8^{b}	88^{a}	87.8^{a}	87^{a}	86.7^{a}	85.4^{a}	83.8^{a}	83.2^{a}	82.1^{a}	79.8^{a}	79.7^{a}
2	87^{a}	86^{b}	85.2^{b}	84.6^{b}	83.3^{b}	82.1^{b}	81.3^{b}	80.4^{b}	78.6^{b}	78.1^{b}	77.6^{b}
3	86.8^{a}	86^{b}	83^{c}	82.3^{c}	81.1^{c}	81.4^{b}	80.1^{c}	78.8^{c}	77^{c}	76.2^{c}	75^{c}
CV*(%)	0.4	0.6	0.3	0.5	0.8	0.5	0.5	0.6	0.6	0.6	0.6
P-valve	0.02	0.0049	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0004	0.0001
SEM**	±0.2	±0.3	±0.1	±0.2	±0.4	±0.2	±0.2	±0.3	±0.2	±0.2	±0.3

Group 1: 1male: 13.3 female,Group 2: 1 male: 11.6 female,Group 3: 1male: 10.5 female, Mean values in a column with different superscripts are significantly (P<0.05) different; *CV: Coefficient of Variation; **SEM: Standard Error of Mean.

Table 3 shows the effects of different sexual ratios on hatchability. Sex ratio used in the present study exerted a significant effect on mounting numbers (mating) in different treatment groups. As it is indicated in table 3, hatchability is increased by increasing the number of males in the mating ratiofrom week 37 to the end of the study. Our results were similar to the results of the studies by Seker et al. (2005), who found statistically higher effect of mating ratio in terms of hatchability.

Also our results are contradictory to the results reported by Deeming and Wadl (2002). They investigated the effect of two mating ratios, i.e. 1M: 8F and 1M: 12F, in commercial pheasant flocks. Hatchability of the flocks with a mating ratio of 1M: 8F had improved significantly. Also it is in disagreement with the report made by Baser et al. (2002) who concluded that the best mating ratio of male and females was 1:3 for optimum hatchability of Japanese quail eggs. Also, Raji et al. (2014) found that

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hatchability of fertile eggs were higher in the mating ratio (male: female) of 1:3 (71.48%) than 1:2 (26.32%). Another study showed that the effect of sex ratio, the hatchability percentage of total eggs set was 49±1.89 and 52.5±1.89% for a sex ratio of 1:2 and 1:3 (male to females), respectively (Karousa et al., 2015). Although Ali et al. (2013) indicated the highest fertility (79%) and hatchability (78%) in 1M: 1Fwhile the lowest fertility (70%) and hatchability (62%) were obtained in 1M: 4F.

The results of present study revealed that hatchability percentage of total eggs set were higher in a sex ratio1:3 than 1:2, but there was non-significant difference (P>0.05) in the hatchability of total eggs set due to sex ratio. These results agreed with those reported by Ipek et al. (2004) andRaji et al., (2014) who found that hatchability of total eggs higher in mating a ratio (male: female) of 1:3 (65.87%) than 1:2 (20.83%).

Present study shows the maximum hatchability was between weeks 31 until 33, this is agreement with also Bayeland Albadry (2012) that showed hatchability reached their highest values at 32 weeks of age; thereafter it significantly (P<0.05) decreased with advancing age and reached its lowest value at 40 weeks of age.

Table 3. Influence of male to female sex ratios on hatchability of broiler breeders (Ross 308)

Groups	Age (week)										
	30	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
1	89.6	90.1	90.0	89.6 ^{b}	88.2 ^{b}	87.6 ^{b}	87.0 ^{b}	87.1 ^{c}	87.0 ^{c}	85.0 ^{c}	83.7 ^{c}
2	89.7	90.5	90.8	90.6 ^{a}	90.7 ^{a}	90.4 ^{a}	90.2 ^{a}	89.8 ^{b}	89.2 ^{b}	88.8 ^{b}	87.4 ^{b}
3	89.2	90.4	90.9	91.0 ^{a}	90.8 ^{a}	90.8 ^{a}	90.8 ^{a}	90.5 ^{a}	90.2 ^{a}	90.0 ^{a}	88.8 ^{a}
CV*(%)	0.4	0.6	0.3	0.5	0.8	0.5	0.5	0.6	0.6	0.6	0.6
P-valve	0.02	0.0049	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0004	0.0001
SEM**	±0.2	±0.3	±0.1	±0.2	±0.4	±0.2	±0.2	±0.3	±0.2	±0.2	±0.3

Group 1: 1 male: 13.3 female, Group 2: 1 male: 11.6 female and Group 3: 1 male: 10.5 female; Mean values in a column with different superscripts are significantly (P<0.05) different; *CV: Coefficient of Variation; **SEM: Standard Error of Mean.

CONCLUSION

From the obtained results it could beconcluded thatalthough increasing the sex ratio had caused the average egg production/female to lower, but hatchability had improved, possibly as a result of more frequent sexual interactions of males and females.

Competing interests

The authors have no competing interests to declare.

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Evaluation of the Nutritive Value and Detection of Contaminants in Feed and Water Samples in Open Poultry Houses of Layer Farms in Gezira State, Sudan

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ABSTRACT

This study was carried out in Gezira state, Sudan to investigate feed and drinking water composition and contamination in open layer houses. Data was collected through individual interviews (questionnaires) of 97 randomly selected poultry farm owners during farms visits. Water and feed samples were collected from 20% of the visited farms and data was analyzed using SPSS. Results indicated that feed samples obtained from farms and mills had higher levels of crude protein than recommended; it was about (23-25%) in all localities, which affect birds' kidney that negatively affect egg production. Metabolizable energy was in the recommended range in all localities. There was high fungal growth and aflatoxins presence in feeds in many localities. Total fungal count was from 113 colonies/g in Greater Medani municipality to 2850 colonies/gr in Almanagil municipality and aflatoxins were from 37.5% in Alkamleen to 66.7% in South of the Gezira and Greater Medani localities. Feed ingredients were also contaminated with fungal growth and aflatoxins presence. Drinking water indicated high pH and total hardness in many localities. There was also high bacterial total count in all localities and E-coli was from 5 colonies/ml in Alhasahesa municipality in the north to Greater Medani municipality mto150 colonies/ml in East of the Gezira locality. It was recommended that measures be taken to ensure poultry feed and drinking water safety in addition to adjusting feed composition to nutrients requirements for the specific production to sustain high productivity.

Key words: Poultry feed, Nutritive value, Contaminants

INTRODUCTION

Feed is one of the most important factor that affects poultry health and production. In keeping a flock of laying birds, the nutritional quality of feed affects egg production, egg size, shell quality and overall flock health, so it must be kept in a safe economical state (Hamre, 2008). Presence of mould (fungi) and mycotoxins in poultry feed from the raw materials is a critical problem overall the world (D'Mello, 2001; Bastianelli and Lebas, 2000).

Most poultry feed have some fungi or spores of fungi development, usually in low amounts. Fungi growth in feed is undesirable, as they can consume nutrients causing loss of energy, fat, protein and vitamins for the animal. That can degrade the nutritive value of feed. Furthermore, fungi growth in feed makes it compacted, difficult to handle, lead to color alteration, different consistency and smell thus being rejected by animals. Apart from that, fungi can produce mycotoxins (Scussel et al., 2006). Mould contamination is wide spread in tropical countries where poultry production and processing are growing rapidly (Van den Berghe et al., 1990; Delgado et al., 1999 and Mabbett, 2004). Poultry are highly susceptible to mycotoxicoses caused by aflatoxins, trichothecenes, ochratoxins and some fusariotoxins (Mabbett, 2004; Opara and Okoli, 2005). Moulds require about 12% moisture, oxygen and energy for their growth. Optimum temperatures for growth may range between 15 and 30°C. However, some moulds such as *Chaetomium thermophilum* and *Penicillium dupontii* are thermophilic, i.e., they can grow at 45°C or higher and fail to grow below 20°C. A few moulds are psychrophilic and unable to grow above 20°C. Significant numbers are psychrotolerant and are able to grow both at freezing point and at room temperature. Fungal growth causes direct losses in volume and quality of feed raw materials and subsequently feed made from them leaving behind some poisonous mycotoxin, which contaminate feed raw materials and finished feeds (Okoli et al., 2006). Feed spoilage by

fungi also results in heating and dustiness. The three most important genera of toxigenic fungi in the tropics are *Aspergillus*, *fusarium* and Penicillium (Kpodo and Bankole, 2005). Hermes (1995) explained that feeds are formulated and manufactured for chickens to meet their nutritional needs at specific ages and production characteristics. The ingredients in these different types of feed are similar; however, the proportions vary to provide the proper level of nutrients for the particular birds being fed. The diets are formulated to give proper nutrition to fast growing chicks. These feed usually contain between 18 and 20 percent of crude protein. Once the birds reach about six weeks of age, a grower feed is substituted for the starters that contains about 15 or 16 percent of crude protein and are formulated to sustain good growth to maturity. After about 14 weeks of age, grower feed can substitute with developer feed; these feed are lower in crude protein than grower feeds (14 to 15 percent) and are formulated to prepare young chickens for egg production.

When birds reach 20 weeks of age or when the first egg is laid, they are fed with feed contain about 16% of crude protein and calcium levels at 2.5-4%, so the chickens will lay eggs with strong shells (Hermes, 1995). Layer hens' ration consists of 2850 - 2950 kcal/kg metabolizable energy and 17-19% crude protein (National Research Council of America, 1974). Ware (2013) mentioned that layer hens need 2800-2900 kcal/kg metabolizable energy and 16-17% crude protein. Water is a critical nutrient for livestock and poultry; it constitutes about 65% of bird life body weight, 75% of egg weight and 85% of chick body weight. So an adequate and safe water supply is essential to production of healthy livestock and poultry (Yousef, 2004). Water is involved in every aspect of poultry metabolism; it plays important roles in body temperature regulation, feed digestion and body wastes elimination (Carter and Sneed, 1987). There are several classes of water pollutants, such as disease causing agents (bacteria, viruses, protozoa and parasitic worms) and oxygen requiring bacteria. When large populations of these bacteria are found, oxygen level in the water is depleted. Also one of the water pollutants is soluble inorganic materials like acids, salts, minerals and toxic metals (Blake and Hess, 2001).

MATERIAL AND METHODS

The present study was conducted in Gezira State in Sudan which lies between latitudes 13^0 - 15.2^0 N and longitudes 32.5^0 - 34^0 E. The total area of the State is 23373 km^2. It is bounded by four States Khartoum in the North, Gadarif in the East, White Nile in the West and Sennar in the South. Gezira State is located within the dry belt climate that is characterized by seasonal and limited raining in the summer months (July-September), the Blue Nile is the most important features of the surface and is characterized by its course and the high percentage of mud in its water during the rainy season. Layer farms owners were randomly selected, during farms visits in the Gezira localities (South of the Gezira, East of the Gezira, Alhasahesa, Almanagil, Alkamleen and Greater Medani) from April 5^{th} to June 10^{th}/ 2010. Feed samples from 20% of the visited farms were collected in addition to feed ingredients samples, as sorghum and cakes. Also samples from different feed mills were collected. The sample size was 1.0 kg. The samples were taken to the laboratory of food microbiology in the Gezira University, for detection of feed contamination. Fungal contamination detection was made by using fungal growth and Susceptibility testing and liquid chromatographic method for determination of aflatoxins was carried out. Proximate analysis of farm diets was carried out according to the method described by the Association of the Official Analytical Chemists (A.O.A.C., 1996) to investigate feeds composition. Water samples were collected in ethanol sterile bottles and the feed samples were collected in paper bags, then they were taken to the laboratory of food microbiology in the Gezira University in Sudan for the above mentioned chemical and biological analysis.

RESULTS

Proximate analysis of poultry farm feed

Farms feed analysis is reported in Table 1. Dry matter was 87.6 to 89.96%, crude protein ranged between 23 to 25% and ether extract was 7.38 to 9.39% in all localities. Crude fiber was 1.5 to 2.04%, nitrogen free extract was 44.57 to 46.4% and ash was 7.46 to 9.11% in all localities while metabolizable energy was between 2827 to 2897 kcal/kg in all localities.

Proximate analysis of feed samples from mills

Table 2. Shows mills feed analysis. In this study mill feeds analysis showed that dry matter was 87.97% to 88.96%, crude protein was 22.54% to 23.88% while ether extracts was 8.58% and 9.55% in Greater Medani and Alkamleen towns, respectively. Crude fiber was 1.69% and 1.98% in Greater Medani and Alkamleen towns, respectively. Nitrogen free extract was 45.2% and 46%, ash was 9.59% and 7.87% while metabolizable energy was 2910.60 kcal/kg and 2938.28 kcal/kg in Greater Medani and Alkamleen towns, respectively.

Contamination of poultry farm's feed

Fungal total count in farm's feed ranged from 113.33 to 2850 colonies/gr in all localities. *Aspergillus flavus* presence was 66.67% in south of the Gezira and Greater Medani localities while it was 50% percent in Alhasahesa and Almanagil localities. Detection of aflatoxins in feed samples was in 50% of farms in east of the Gezira, Alhasahesa and Almanagil localities (Table 3).

Contamination of mill's feed

Table 4 shows fungal and aflatoxins presence in mill feed. In Medani mills the fungal total count was 151.25 colonies/gr. *Aspergillus flavus* rate was 37.5% and aflatoxins level was 33.33%, and in Alkamleen mills fungal total count was 176.04 colonies/gr, *Aspergillus flavus* rate was 25.0% and there was no aflatoxins detected. Contamination of feed ingredients with fungi is shown in Table 4.

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Feed ingredients fungal contamination

Contamination of feed ingredients with fungi is shown in table 5. The results indicated that there was fungal growth in most sorghum and groundnut cake samples, but no fungal growth that could be detected in wheat bran. Samples of Sorghum were found to be contaminated with *Aspergillus flavus* in South of the Gezira and Grade Medani localities reaching 66.7%, beside 50% in Almanagil locality. On the other hand Groundnut cake contamination reached100% in Almanagil and was 80% in South of the Gezira localities while it reached to 50% in Alkamleen locality. Maize contamination was also detected in east of the Gezira and Alkamleen localities reaching to 50% (Figure 1). Contamination of feed ingredients with aflatoxins is illustrated in figure 2. Sorghum contamination was 100% in Almanagil, 33.3% in south of the Gezira and Greater Medani localities**.** Groundnut cake contamination was 50% in East of the Gezira and Alkamleen localities, while it was 40% in South of the Gezira locality. Maize contamination was detected in Alkamleen locality reaching to 50%.

Table 1. Analysis of poultry feed in different farms of Gezira state in Sudan

Locality	Mean Moisture (%)±SD	Mean DM (%)±SD	Mean CP (%)±SD	Mean EE (%)±SD	Mean CF (%)±SD	Mean NFE (%)±SD	Mean Ash (%)±SD	Mean ME (kcal/kg)±SD (kcal/kg)
South of Gezira	11.5±1.13	88.94±1.36	24.73±0.81	8.27±0.53	1.50±0.19	44.57±2.12	9.01±1.44	2867.43 ±18.72
East of Gezira	9.60 ±0.13	89.96±0.50	25.08±0.59	7.63±0.25	1.91±0.90	45.46±1.58	8.08±0.61	2860.84 ±14.61
Alhasahesa	11.42 ±0.91	88.59±1.03	24.35±0.57	9.39±1.43	2.04±0.32	45.36±0.95	7.46±0.18	2963.98 ±7.82
Almanagil	11.0 ±0.13	88.59±1.03	23.15 ±0.3	8.65 ±1.0	2.06±0.28	46.20±0.99	7.90±1.32	2897.09 ±10.59
Alkamleen	11.27 ±1.34	87.60±3.87	25.06±1.61	7.38±0.82	1.68±0.27	45.02±2.01	9.11±1.18	2827.24 ±10.59
Greater Medani	11.92 ±.82	88.08±1.84	23.63 ±0.3	8.10±1.25	1.69±0.48	46.40±2.24	8.26±1.14	2878.97 ±16.09

SD: Standard Deviation, DM: Dry Matter, CP: Crude Protein, EE: Ether Extract, CF: Crude Fiber, NFE: Nitrogen Free Extract, ME: Metabolizable Energy, calculated according to the equation of Lodhi et al. (1975).

Table 2. Analysis of feed from feed mills in Medani and Alkamleen cities in Gezira state, Sudan, 2010

Mill site	Mean Moisture (%)±SD	Mean DM (%)±SD	Mean CP (%)±SD	Mean EE (%)±SD	Mean CF (%)±SD	Mean NFE (%)±SD	Mean Ash (%)±SD	Mean ME (kcal/kg) ±SD
Medani	11.05 ±1.14	88.96 ±1.14	23.88 ±0.63	8.58 ±0.53	1.69 ±0.14	45.21 ±1.93	9.59 ±0.85	2910.60±11.51
Alkamleen	12.03 ±0.77	87.97 ±0.98	22.54 ±1.03	9.55 ±0.98	1.98 ±0.43	46.03 ±1.88	7.87 ±1.88	2938.28±19.73

SD: Standard Deviation, DM: Dry Matter, CP: Crude Protein, EE: Ether Extract, CF: Crude Fiber, NFE: Nitrogen Free Extract, ME: Metabolizable Energy calculated according to the equation of Lodhi et al. (1975).

Table 3. Microbiological analysis of feed from poultry farms in different localities in Gezira state, Sudan, 2010

Locality	Mean Fungi total count (colonies/gr) ±SD	*Aspergillus flavus* presence (%)	Aflatoxin presence (%)
South of the Gezira	146.67 ± 86	66.7	33.33
East of the Gezira	1209.15 +114	50	50
Alhasahesa	311.13±41	50	50
Almanagil	2850.0 ± 154	50	50
Alkamleen	176.04 ±15.67	37.5	12.5
Greater Medani municipality	113.33 ± 2.75	66.7	33.3

SD: Standard Deviation

Table 4. Microbiological Analysis of poultry rations from feed Mills in Medani and Alkamleen Localities in Gezira state, Sudan, 2010

Town	Mean Fungi total count (colonies/gr)±SD	*Aspergillus flavus* presence (%)	Aflatoxin presence (%)
Greater Medani	1512.5 0±15.75	37.5	33.33
Alkamleen	1760.40 ±15.46	25	-ve

SD: Standard Deviation; ve: not detected

Table 5. Fungal total count of the main feed ingredients in poultry farms in different localities in Gezira state, Sudan, 2010

Locality	Fungal total count (colonies/gr)				
	Mean Sorghum±SD	Mean Groundnut cake±SD	Mean Sesame cake ± SD	Mean Maize±SD	Mean Wheat bran±SD
South of the Gezira	76.67±3.7	176±8.8	25±0.7	30±0.0	-ve
East of the Gezira	115.00±12	-ve	-ve	-ve	-ve
Almanagil	75.00±3.5	1295±9.9	-ve	-ve	-ve
Alkamleen	30.0±6	190±23	-ve	350±70	-ve
Greater Medani	-ve	30±2	20±1	-ve	-ve

SD: Standard Deviation; ve: not detected

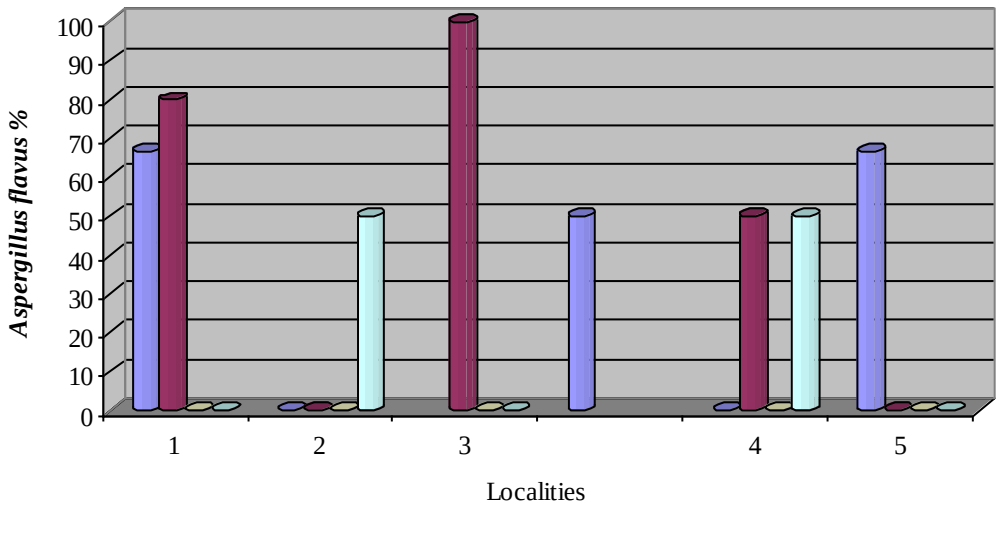

Figure 1. *Aspergillus flavus* contamination in main feed ingredients in poultry farms in different localities of Gezira state, Sudan 2013. (1: South of the Gezira, 2: East of the Gezira, 3: Almanagil, 4: Alkamleen, 5: GreaderMedani).

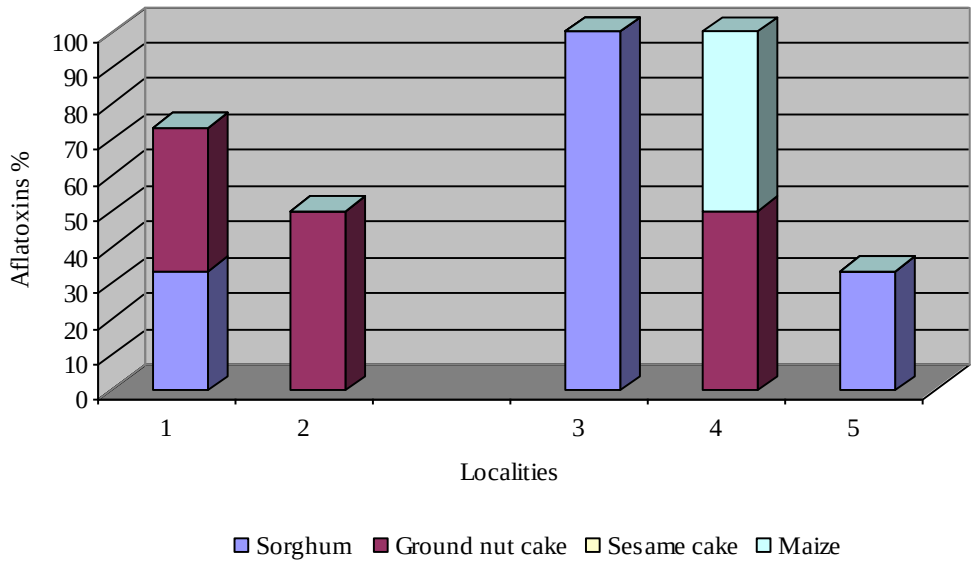

Figure 2. Aflatoxin presence in main feed ingredients in poultry farms in different localities of Gezira State, Sudan, 2010. (1: South of the Gezira, 2: East of the Gezira, 3: Almanagil, 4: Alkamleen, 5: GreaterMedani).

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Contamination of poultry drinking water

The pH level in samples collected from the different localities was around 7.17 to 7.66 pH; total hardness that found in this study was about 164 to 296 mg/l. Nitrate levels were less than 1.0 mg/l except in Alkamleen it was about 3.71 mg/l, sodium level was around 40 to 62 mg/l, calcium level was in range of 4 to 35.75 mg/l and iron level was 2.1 mg/l in Greater Medani, 1.25 mg/l in east of the Gezira localities while it was about 1.0 mg/l in Almanagil locality (Table 3).Water bacterial total count in the different localities was about 1315 to 6425.78 colonies/ml, while E-coli bacteria detection reached about 69.25 to 150 colonies/ml in the different localities (Table 4).

Table 6. Chemical analysis of drinking water in poultry farms in different localities in Gezira state, Sudan, 2013

Locality	Mean pH (log[H+]) ±SD	Mean Total Hardness (mg/l)±SD	Mean Alkalinity (milliequivalent/liter) ±SD	Mean No_3 (mg/l)±SD	Mean Na (mg/l)±SD	Mean K (mg/l)±SD	Mean Ca (mg/l)±SD	Mean Fe (mg/l)±SD
South of the Gezira	7.17±0.25	212.67±56.54	243.30±74.21	0.12±0.01	65.30±22.3	2.02±0.26	33.54±19.07	-
East of the Gezira	6.20 ±0.14	164±5.66	220±0.00	0.17 ± 0.01	40.50±1.41	1.50±0.00	4.13±0.18	1.25±0.56
Alhasahesa	7.46 ±0.26	278±15.97	240±84.85	1.13±0.22	80±2.12	1.40±0.13	26.19±09.53	-
Almanagil	7.66 ±0.78	235.5±36.06	410 ±14.14	1.41±0.02	268.50±2.12	2.45±0.21	21.25±1.77	1±0.42
Alkamleen	7.55±0.16	291.5±12.93	346.25±55.27	5.59±0.13	61.31±29.21	3.65±0.88	30.28±3.75	-
Greater Medani	6.52±1.21	296±52	226.67±30.55	0.1±0.01	19.33±8.58	2.13 ±0.23	35.75±03.81	2.04±0.98

SD: Standard Deviation

Table 7. Microbiological analysis of drinking water in poultry farms in different localities in Gezira state, Sudan, 2013

Locality	Mean Bacteria total count (colonies/ml)±SD	Mean E.coli bacteria (colonies/ml)±SD
South of Gezira	8850 ±113.40	91.17 ±9.17
East of Gezira	3675±51.26	150±12.13
Alhasahesa	1315±15.34	50±7.07
Almanagil	4250±106	35±9.50
Alkamleen	6425.78±105.12	69.25±5.47
Greater Medani	4666.67±15.50	76.67±15.28

SD: Standard Deviation

DISCUSSION

Feed and feed ingredients contamination

The present study proved that samples of poultry feed collected from different Gezira State localities were highly contaminated with fungi, especially *Aspergillus flavus.*

According to Lazzari (1993) and Scussel et al. (2006), fungal availability in feed or feed ingredients will lead to losses of energy, fats, proteins and vitamins. Moreover it will also make the feed more compacted, difficult to handle and rejected by birds. The presence of fungi in feeds will also lead to the production of mycotoxins in the feed especially aflatoxin, and results of this study is similar to those of Bastainaelli and Le Bas (2002) who confirmed the presence of *Aspergillus flavus* in poultry feed. Aflatoxins were reported by many authors to cause liver, kidney and nervous tissue damages, resulting in reduction in animal production and performance and their presence in the animal products (eggs and meat) will threaten human health (Bartov, 1982; Lazzari, 1993 and Shimoda, 1979).

Water contamination

Water pH found in present study was about 7.17-7.66, so this result was disagree with findings of Fairchild et al. (2006) who mentioned that a pH of about 6.0 to 6.8 is preferred for poultry production, low or high pH can affect bird's health. Total hardness that recorded in the present study was about 164 - 296 mg/l and it was differing from the results shown by Blake and Hess (2001), and results that reported by Carter and Sneed (1987) who suggested that about 60-180 mg/l hardness would be safe to poultry drinking water. Nitrate rate in this study was less than 1.0 mg/l in all localities except in Alkamleen locality it was about 3.71 mg/l, Na level was around 40-62 mg/l, Ca level was about 4-35.75 mg/l and Fe level was around 2.1 mg/l in

Grade Medani locality and about 1.25 mg/l in East of the Gezira localities; while it was about 1.0 mg/l in Almanagil locality. These findings confirmed the results obtained by Carter and Sneed (1987) who reported that about 25-43 mg/l of Nitrates and about 32 mg/l of Na was suitable for bird drinking water and results observed by Blake and Hess (2001) who mentioned that 400 mg/l of Ca and 25 mg/l of Fe was suitable for bird drinking water.

In the present study, poultry drinking water bacterial total count was reaching about 6425 colonies/ml, while E-coli level was around 150 colonies/ml. The presence of bacteria, especially E-coli in water is a serious problem. According to Blake and Hess (2001), drinking water for poultry production must be free from bacterial contamination. The level of E-coli in the present study (150 colonies/ml) was even far more than the accepted level of coliform bacteria (50 colonies/ml) (Blake and Hess, 2001).

CONCLUSION

The study concluded that rations formulated for poultry farms in different localities of Gezira State are not prepared in accordance with standards to meet birds' nutrients requirements. Feed ingredients used in poultry rations' preparation mills are contaminated with bacteria, fungi and moulds containing detrimental residues such as aflatoxins. Water qualities have shown to be under the recommended standards in their content of total dissolved solids, pH and microbial contamination safety. Drinking water analysis indicated that pH was more than 7.0. Total hardness was found to be164 -296 mg/l and high sodium and an iron level in many localities was detected. Bacterial total count and E-coli bacteria were more than recommended.

It is recommended that more studies be carried out on poultry feed nutritive value, feed contamination and water quality in Gezira the state of Sudan and measurements be taken to alleviate all these constraints.

Competing interests

The authors have no competing interests to declare.

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Analysis of Urban Household Demand for Poultry Production in Ado Local Government Area of Ekiti State, Nigeria

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ABSTRACT

The study investigates the urban household demand for poultry products in Ado Local Government areas of Ekiti State, Nigeria. A two-stage sampling technique was used to select respondents for the study. Ten wards were randomly selected in Ado local government area and this was followed by a random selection of twelve households from each selected ward, making a total number of 120 respondents used for the survey with the aid of structured questionnaires. The analytical techniques used include descriptive statistics like mean, minimum value, maximum value; standard deviation and linear regression analysis were used to analyze the relationship between the household's socio-economic characteristics and the amount spent on poultry products. The results obtained revealed that majority of the household (45.4) percent believed that taste of the poultry product determine the demand for poultry products, the mean amount spent on poultry product monthly is ₦4,918.61(24.59USD) which is very low, it may be due to the high price of poultry products or easy accessibility to a close substitute which made respondents demand for more substitutes than poultry products and the regression analysis for the determinant of households demand for poultry products reveals that variables such as "years spent in formal education, household size and average monthly income" had positive effect on amount spent on poultry products. There should be a policy measure that will ensure increase in purchasing power of the people's income which will invariably contribute positively to the improvement of nutritional status of the people and government price intervention program should be introduced in order to stabilize the fluctuation of poultry products prices.

Key words: Analysis, Urban, Household, Demand, Poultry Products

INTRODUCTION

Since the 1970s in Nigeria, global production and consumption trade of poultry meat has grown faster than any other meat. During the 1990s when demand growth showed for other meats, including fish, demand growth for poultry meat accelerated and poultry continue to lead the expansion of meat trade. Poultry is crucially important in the context of agricultural growth and important in the diets of people in Nigeria. The sub-sector is particularly important in that it is a significant source for the supply of protein and nutrition, in a household's nutritional intake. It is an attractive economic activity as well, especially for women. Livestock farming has remained an essential component in the agricultural sector of the Nigerian economy. This is true because livestock is a good source of animal protein, which is needed for a proper and balanced diet. The Food and Agricultural Organization (FAO, 2010) recommended that an average of 200 gram of animal protein is required per day for healthy living in the developing countries. This therefore, means that the general wellbeing of the people is directly dependant on the amount of animal protein consumption available to them. Although, FAO, 2010 recommended the average protein requirement for healthy living and maintained that the meat protein consumption in most African countries is very low, at a level of 25 gram. Yet in Nigeria, the consumption is even lower especially in the southern and eastern part of Nigeria, where recently human nutritionists have observed that the production of animal protein has not been enough to meet the demand of the rapid population growth (Obi, 2003). He asserted that much of the animal protein intake available to the southern and eastern part of Nigeria comes from the north in the form of cattle, rams and goats.

Comparative statistics by Ademosun (2000) puts Nigeria's total Poultry meat production at 810,000 tons for a population of about 110 million resulting in a poultry meat production index of 22 gram per capital consumption, per day. Sonaiya (1982) had rightly envisaged that as consumers become more articulate and organized their demand for wholesome animal protein will exert a powerful influence upon quality production methods and strategies. He added that recent increases in income expenditure of urban dwellers have tendencies to stimulate greater demand, not only for quality but also quantity of meat products. Today, the increasing human population in the face of inelastic

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production, strategies appears to have widened the demand and supply gap and accentuates society needs for meat products. Regmi et al. (2002) supported this view and noted that, the unprecedented growth that has occurred in the last half-century has created an additional demand for meat and general food in developing countries. Beside the failure of meat production capacity to match with the human population growth, the distribution of livestock in Nigeria is apparently lopsided. Composite transportation cost incurred, coupled with remote distance between major meat producing areas and consuming urban centers together make the value of wholesome beef, mutton, pork, and chicken and dog meat often unaffordable (Mdafri and Brorsen, 1993). As the poultry industry is expanding with the increasing number of households involved in the raising of domestic fowls, turkeys, goose, ducks and all the likes, the problems of malnutrition persists. It is very difficult for an average Nigerian, to consume any of the poultry products either chicken meat or egg, on the scales of international nutrition requirement. This can be traced to the high price of the products, which makes poultry products appear infrequently on many of our tables, except during the festive periods.

The low level of consumption makes the issue of malnutrition to be persistent. Another observation is the fact that the demand for this product is still far higher than its supply, this arises from higher pricing and importation of both chicken and eggs from other countries. Nigeria has the largest population in Sub-Saharan Africa. About 47% of the population resides in urban areas where the population growth rate is estimated at three times more than that in rural areas (World Bank, 2004). The suggested shift in increased food demand from the rural to the urban areas, government policies tend to support the urban dwellers at the detriment of the rural areas. Over the past three decades, rural households have been significantly poorer than urban households. However, while urban poverty has increased, rural poverty has decreased, especially after the post-adjustment period 1995 to date (Canagarajah and Thomas, 2001). Urbanization is therefore a key non-income factor explaining the changes in demand for animal protein (Ahmed and Gruhn, 1995).

The concept of demand helps to explain everyday's economic problems in the demand and consumption of poultry products in the economy. The volume of production is greatly influenced by the demand structure. The demand by an individual for a commodity or service may be defined as the schedule of the amount of poultry products that would be purchased by the person at various given times and places (Akinleye, 2007).

When consumers increase the quantity of demand at given price, it is referred to as an increase in demand, increase in demand could also come from a change in taste, income, price of the products, price of close substitute, information, fashion and so forth. But if there is a decrease in demand the price will decrease and quantity will also decrease. There are several main factors, which determine the level of the demand and schedule for a particular commodity by an individual consumer or household. For a given demand schedule, these factors are assumed to be constant or given, any changes in those given factor will cause a shift in the demand schedule. The main determinants of an individual's demand of a household are; their preferences or personal taste, level of the income at the disposal of a consumer, the population (number of people in household), the government policies, the level of prices of a close substitute, the prices of complementary goods etc.

First and foremost, the level of income at the disposal of a consumer will determine the level of consumption and demand. A positive income effect is expected from a product that is considered superior, meaning that more of the product will be purchased while a negative income effect is associated with a product considered inferior; Furthermore, the level of prices of other commodities is also a major determinant of the level of a particular demand schedule. The prices of close substitutes are another factor. The strength of demand is theoretically determined by the price of the commodity. Also expectation regarding future prices of commodities affects the height of the demand schedule of a consumer for a particular commodity. Moreover, the scale of consumer preferences or personal taste determines the level of the demand schedule for a commodity. Thus any shift in the scale of preference will lead to a change in the demand. Any change in government policies may affect the demand. When government imposes tax on goods, thereby increasing the effective price of the commodity. Any rise in price will determine the demand or purchasing power of an individual or household. Also an increase in income tax will see a fall in the demand, as people will have less money left in their pocket to spend. Whereas a decrease in income tax will result in the increase of demand for product and service because people now have more disposable income (Akinleye, 2007). The Age of the members of household most especially the head of the household affects or determines the quality and quantity of what will be consumed and demanded among household (Ajewole and Omonona, 2005).The size of a family or household significantly affects or determines the relative level of consumption and demand among Nigerian household (Aboyade, 2005). An increase in

household size will result in the rise in demand of poultry products.

In addition, social cultural factors affect what will be demanded, different people have taste for different goods and considering the adage that says, "One man's food is another Man's poison". Different cultural groups and people have norms and laws guiding the consumption of various foods. This invariably affects the type of food that will be demanded for, and also the level of demand of these foods (Olayemi, 1998). Difference in geographical location is very crucial in the demand for poultry products. There is marked between urban and rural dwellers while a rural based household may be restricted to the type of poultry produced in the locality, urban counterparts may have access to variety of poultry products produced outside its areas thus affecting the demand for poultry products. In most cases livelihood determines the pattern of poultry product demand. Livelihood comprises of the capabilities assets (Including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and asset both now and in the future while not undermining the natural bases (Carter and Barrett, 2006). This study therefore seeks to analyze the urban household demand for poultry products in Ado local Government Areas of Ekiti State, Nigeria.

MATERIAL AND METHODS

Study area

Ado local government of Ekiti State, Nigeria is located on latitude 7^0 35' and 74^0 47' North of the equator and longitude $5^0$11' and $5^0$16 East of the Greenwich meridian. Ifelodun/Irepodun Local government and East and South by Gbonyin, Ikere and Ekiti South West local government areas bound it on the North and West. The local government has a population density of 43,986 person square kilometer; it is the state capital of Ekiti state with 13 wards and is the commercial center of the state that is why it was selected as the study area.

Study period

The study was carried out during 2012. This period is the festive period when the request for poultry products is expected to be high. This period would therefore give a good understanding for consumers' demand.

Sampling technique

A two-stage sampling techniques was used to select respondents for the study. Ten wards were randomly selected in Ado local government area, Nigeria and this was followed by a random selection of 12 households from each selected ward, making a total number of 120 respondents used for the survey.

Data collection

Data were collected with aid of well-structured questionnaire in Ado local government area, Nigeria, which included socio-economic characteristics of the household as well as demand pattern for poultry products by the household.

The analytical techniques used in the study include:

Descriptive statistics like mean, minimum value, maximum value, standard deviation were used to analyze the urban household's socio-economic characteristics and the factors that affect the demand for poultry products in Ado Ekiti metropolis. Linear regression model was used to analyze the relationship between the household's socio-economic characteristics and the amount spent on poultry products. Significant levels for each independent variable were considered using the P-values by multiplying each value by 100. The results obtained would determine the significance level that is, if it falls below 1, it implies that it is significant at1% level while if significant at 5% means the value ranges between 1.1-4.9, and between 5-9.9 implies significance at 10% level.

RESULT AND DISCUSSION

The socio-economic characteristics of respondents

The socio-economic characteristic of the households in Ado local government has been carefully identified and studied because they can influence the households demand for poultry products either directly or indirectly (Table 1).

Effective factors on demand of poultry products

The determinants of demand for poultry products are the possible factors that can affect the demand for poultry products in a household, which vary from one household to the other. In this section, the determinants are analyzed by using frequency and percentage distribution (Table 2). Table 2 shows that majority of the household 45.4 percent believed that taste of the poultry product determine the demand for poultry products while 29.4 percent believed that income at their disposal determined their demand for poultry products, 21.0 percent believed that price of the poultry products determines their demand and 5.0 percent believed that price of other substitutes determines their demand for poultry products.

Table1. Socio-economic characteristics of urban household demand for poultry products in Ado- Ekiti, Nigeria in 2012.

Socio-economic characteristics	Frequency	Percentage
Gender		
Male	63	52.5
Female	57	47.5
Total	120	100
Age (Years)		
≤ 30	52	43.6
31 – 40	24	20.1
41 – 50	23	19.2
51 – 60	14	11.7
61 and above	7	5.6
Total	120	100
Marital status		
Single	44	37.0
Married	76	63.0
Total	120	100
Educational Level		
No Formal Education	4	3.2
Primary Education	5	4.2
Secondary Education	13	10.9
College of Education	20	16.8
Polytechnic/University	76	63.1
Others	2	1.7
Total	120	100
Occupation		
Farmer	9	7.5
Artisan	13	10.9
Trader	30	25.2
Unemployed	2	17.2
Civil servant	57	47.1
Public Servant	9	7.6
Total	120	100
Household size		
1 – 2	14	11.8
3 – 4	35	29.4
5 – 6	42	35.2
7 and above	29	24.4
Total	120	100

Table 2. Determining effective factors on demand of poultry products in Ado Ekiti, Nigeria in 2012.

Factors	Frequency	Percentage
Income	35	29.4
Price of poultry products	25	21.0
Price of Other substitutes	6	5.0
Taste	54	45.4
Total	120	100.0
Number of Times		
Everyday	42	35.6
One day Interval	26	21.8
Once in a Week	36	30.3
Once in a Month	13	10.9
Occasionally	3	2.4
Total	120	100.0
Household		
Substitute	95	79.1
No Substitute	25	21.0
Total	120	100.0
Reason		
Easy accessibility	31	25.8
Price	38	31.7
Relative distribution	51	42.5
Total	120	100.0

It can be deduced that, taste and income respectively are the major determinant of household demand for poultry products. However, how often a household demand for poultry product will affect the quantity demanded for a period of time since this will either increase or decrease the market demand.

It was shown in Table 2, that 35.6 percent of the households demands for poultry products every day, 21.8 percent of the household demands for poultry products at one day interval, 30.3 percent of the household demand for poultry products once in a week, 10.9 percent demand poultry products once in a month and 2.4 percent demand for poultry products at their leisure period. Since most of the respondents demand for poultry products seems to be frequent, i.e. more people demand for poultry products within the week, there is tendency that the households will demand for higher poultry products, which will affect the demand pattern. It was also revealed that 79.7 percent of the households' demands for close substitute while 21.0 percent did not demand for any close substitute except poultry products.

It can be deduced that higher percent of the household demand for close substitute, which will have influence on the demand for poultry products. The demand for close substitute to poultry product for any reason will influence the demand for poultry products because the two products that are the poultry product and close substitute like beef, will compete for available resources. Also, 42.5% of the respondents demand for close substitute based on the price of the substitute and 25.8 percent demand for close substitute based on the easy accessibility of the close substitute. It can be deduced that the highest percent of the respondent demand for close substitute based on the relative distribution.

Effect of income and price on demand for poultry products in Ado-Ekiti, Nigeria in Year 2012

For a normal good, an increase in income of consumers will increase the demand for poultry products. Thus, the quantity demand of poultry products is also directly related to income. Also an increase in price will result in the decrease in quantity demanded of poultry product.

Table 3 presents the effect of income and price on demand for poultry product. From the table 21.1 percent of the respondents earned below 30,000 Naira (150 Dollars) monthly, 24.1 percent earned between 30,000 - 50,000 Naira in a month, 17.5 percent of the household earned between 71,000 - 90,000 Naira monthly, 4.1 percent of the household earned between 91,000 - 110,000 Naira as monthly income, 5.0 percent earned between 111,000 - 130,000 Naira monthly, 5.9 percent earned between 131,000 - 150,000 Naira

monthly and 15.8 percent of the household earned 151,000 Naira and above monthly. The mean income of the households is 101,013.75 Naira (505.07 USD) from all sources. However, Income determines the demand for poultry products and putting into consideration the average household size and the cost of living, majority of the household were middle-income earners, which will influence their demand for the products.

Table 3. Effect of income and price on demand for poultry products in Ado Ekiti, Nigeria in 2012

Monthly Income ₦ (USD)	**Frequency**	**Percentage**
>30,000 (150)	24	21.1
30,000(150)–50,000(250)	29	24.1
51,000(255)–70,000(350)	21	17.5
71,000(355)–90,000(450)	8	6.6
91,000(455)–110,000(550)	5	4.1
111,000(555) – 130,000(650)	6	5.0
131,000(655) – 150, 000(750)	7	5.9
151,000(755) and above	20	15.8
Total	120	100.0
Amount Spent On Poultry Naira ₦ (USD)		
Less than 1,000(5)	21	17.6
1,000(5) – 4,000(20)	44	36.6
5,000(25) – 9,000(45)	35	29.3
10,000(50) – 14,000(70)	12	10.0
15,000(75) – 19,000(95)	3	2.5
20,000(100) and above	5	4.1
Total	120	100.0

Also from the Table 3, 17.6 percent of the respondents spent less than 1,000 Naira (5USD) on poultry products in a month, 36.6 percent spent between 1,000 - 4,000 Naira on poultry products, 29.3 percent spent 5,000 - 9,000 Naira on poultry products in a month while 10 percent spent between 10,000 - 14,000 Naira on poultry products, 2.5 percent spent between 15,000 - 19,000 Naira on poultry products and 4.1 percent spent 20,000 Naira and above on poultry products in a month. Since the mean amount spent on poultry product monthly is 4,918.61 Naira (24.59USD) which is very low, it may be due to the high price of poultry products or easy accessibility of close substitute which made respondents' demand for more substitute than poultry products. The amount a household is willing to spend on poultry product will determine their demand pattern.

The relationship between the household socio-economic characteristics and the amount spent on poultry products

Table 4 reveals the regression analysis for the determinant of households demand for poultry products. Variables; "years spent in formal education, Household size and average monthly income" had positive effect on the amount spent on poultry products (Dependent Variable). It however implies that the higher the years spent in formal education, household size and average monthly income, the higher the amount spent on poultry products. Out of these positive correlated variables, only "Average monthly income" was significant at 1%, household size and years spent in formal education were significant at 10%.

Table 4. Determinants of households demand for poultry products in Ado Ekiti, Nigeria in 2012.

Variables	**P-value**
X_1	0.589
X_2	0.292
X_3	0.057*
X_4	0.066*
X_5	0.000***
X_6	0.890

X1 = Age, X2 = Marital Status, X3 = Years spent in formal education, X4 = Household size, X5 = Average monthly income, X6=Frequency of demand for poultry products; *Significant at 10%; ***Significant at 1%.

CONCLUSION

Comprehensively, there is now a wider understanding about the household demand of poultry products in Ado Local Government Area of Ekiti State, Nigeria. The findings showed that taste and income level of the respondents determine the demand for poultry products. However, the average amount spent on poultry products was very low compared to average amount of income this is because of the relative distribution of close substitute like fish. Finally, as the household level of education increases, there is an increase in the demand for poultry products, the numbers of people living in a household (household size) also play an important role in the demand for poultry product.

Recommendation

The importance of demand for poultry products cannot be overemphasized since it is the major source of animal protein. It is therefore recommended that, the poverty status of the area should be addressed by the government, this will go a long way in increasing the living standard of the people and change the mentality that poultry meat belong to the few affluent people except on festival days. There is the need for systematic introduction of the technology for collection, processing, storage, and distribution of poultry products to the market by the government to ensure regular supply of products at stabilized market price. There should be policy measure that will ensure an increase in purchasing power of the people's income, which will invariably contribute positively to the improvement of nutritional status of the people. Government price intervention program should be introduced in order to stabilize the fluctuation of poultry products prices. Finally, there should be setting up of standards for grading and policy for appropriate pricing of product that will give remunerative price to farmer, encourage

him to continue and improve production. On the other hand the consumer will get quality processed products at a reasonable and affordable price.

Competing interests

The authors have no competing interests to declare.

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A Review on Effects of Probiotic Supplementation in Poultry Performance and Cholesterol Levels of Egg and Meat

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ABSTRACT

Probiotics are live microbial food/feed ingredients that have a beneficial effect on health that stimulates the growth of beneficial microorganisms and reduces the amount of pathogens, thus improving the intestinal microbial balance of the host and lowering the risk of gastro-intestinal diseases. Probiotics can be harmful to debilitated and immuno-compromised populations. An accurate dosage of administration has yet to be established despite the wide-use of probiotics. Probiotics have antimutagenic, anticarcinogenic, hypocholesterolemic, antihypertensive, anti-osteoporosis, and immunomodulatory effects. *Lactobacillus*, *Bifidobacterium*, *Leuconostoc*, *Enterococcus*, *Lactococcus*, *Bacillus*, *Saccharomyces*, *Aspergillus* and *Pediococcus* species are most commonly used probiotics in poultry production. When supplemented to chicken probiotics improve feed-intake, growth performance, meat quality, egg production, egg quality and have cholesterol lowering potential in poultry products. However, some studies reported no significant effect of probiotics on feed-intake, production traits, products' quality and cholesterol level.

Key words: Broiler, Feed intake, Hypocholesterolemic, Layer, Probiotic

INTRODUCTION

A probiotic was defined as a live microbial feed supplement that beneficially affects the host animal by improving its microbial intestinal balance (Fuller, 1989). Probiotics stimulates the growth of beneficial microorganisms and reduces the amount of pathogens thus improving the intestinal microbial balance of the host (Fuller, 1989; Chiang and Pan, 2012). Intake of Probiotic lowers the risk of gastro-intestinal diseases by stimulating the growth of beneficial microorganisms (Fuller, 1989; Chiang and Pan, 2012). Supplementation if probiotics alleviates the problem of lactose intolerance, the enhancement of nutrients bioavailability, and prevention or reduction of allergies in susceptible individuals (Isolauri, 2001; Chiang and Pan, 2012). Probiotics are reported to have also antimutagenic, anticarcinogenic, hypocholesterolemic, antihypertensive, anti-osteoporosis, and immune modulatory effects (Chiang and Pan, 2012).

Moreover, it has been shown that probiotics could protect broilers against pathogens by colonization in the gastrointestinal tract (Nisbet et al., 1993; Hejlicek et al., 1995 andPascual et al., 1999) and stimulation of systemic immune responses (Muir et al., 1998; Que´re´ and Girard, 1999).The World Health Organization (WHO) has predicted that by 2030, cardiovascular diseases will remain to be the leading causes of death. The report indicates hypercholesterolemia contributed to 45% of heart attacks in Western Europe and 35% of heart attacks in central and Eastern Europe from 1999 to 2003. The WHO reported that unhealthy diets lead to increased risk of cardiovascular diseases.

Supplementation of probiotics may avert the use of cholesterol-lowering drugs in people with high cholesterol level profile (WHO, 2008).

There are researches conducted on the effects of supplementation of probiotics, prebiotic and symbiotic on the quality of poultry products in different parts of the world on different breed of hens. Therefore, the objective of present paper is to review the studies on the effects of probiotic supplementation on poultry diet feed intake, growth rate, egg production and products' cholesterol level.

Controversies in probiotics

Probiotics are generally non-pathogenic microorganisms supplemented to both human and animals' diet, but they could be infectious, especially in debilitated and immuno-compromised populations (Peret-Filho et al., 1998).

Some species of *Lactobacillus*, *Bifidobacterium*, *Leuconostoc*, *Enterococcus and Pediococcus* have been isolated from infection sites (Land et al., 2005). Rautio

et al. (1999) reported two probiotic bacterium causing infection.

Lactobacillus rhamnosus strain indistinguishable from *Lactobacillus rhamnosus* GG has been isolated from a liver abscess from an elderly lady with a history of hypertension and diabetes mellitus. Strains of probiotics have also been found to exhibit antibiotic resistance and have raised concerns about horizontal resistant gene transfer to the host and the pool of gastrointestinal pathogenic micro flora (Huys et al., 2006). A low risk probiotics have to be accepted when recommended to immune-compromised individuals, but the risk to benefit ratio needs to be clearly established in such cases.

Mode of inclusion

Although the hypocholesterolemic potential of probiotics and prebiotics has been widely studied, an accurate dosage of administration has yet to be established (Ooi and Liong, 2010). Culture mix indicated a minimum presence of 1.04×10^8 colony forming unit/gram (*Lactobacillus acidophilus*, *Lactobacillus casei*, *Bifidobacteriumthermophilus* and *Enterococcus faecium*) was used by Ghavidel et al. (2011). According to Mansoub (2010), reported the dosage of basal diet with drinking water containing 0.5– 1%. A study by Ramasamy et al. (2008) used Lyophilized and the concentration of viable *Lactobacillus* cells diluted to 9log colony forming unit/gram with corn starch.

On the other hand, Mahdavi et al. (2005) included four probiotic concentration (0, 400, 1000 and 2000 gram ton^{-1} feed providing 0, 1.28×10^6, 3.2×10^6 and 4.6×10^6colony forming unit/gram feed concentration). Bioplus 2B, a commercial probiotic preparation, was used in this study. The product contained 2 strains of bacilli, *Bacillus subtilis* and *Bacillus licheniformis* with a minimum of 3.2×10^9colony forming unit/gram of the product. A review of past studies has revealed that the effective administration dosages of probiotics vary greatly and is dependent on the strains used and the clinical characteristics of subjects, such as lipid profiles. Although probiotics have been delivered in the range of 10^7 to 10^9 CFU/day in animals (Ha et al., 2006).

Effects on feed intake

Rise in feed and water consumption is recorded in laying hens fed with Liquid Probiotics Mixed Culture (LPMC) containing two type microorganisms, *Lactobacillus* and *Bacillus* species (Raka et al., 2014).Inclusion of probiotic caused no significant increase in feed consumption, egg production and egg weight (P>0.05) (Mahdavi et al., 2005).Ramasamy et al. (2008) reported that supplementation of probiotic *Lactobacillus* cultures did not influence the Feed Intake (FI), egg production or egg mass of hens throughout the 48-week period. Zhang and Kim (2014) reported an increase body in FI in chicken fed with multistrain probiotics compared with that in control group fed basal diet. Saadia and Nagla (2010) reported FI values of different treated groups were approximately similar and lacked significance with layer flock that fed with *Saccharomyces cerevisiae.*

However, feeding viable *Lactobacillus* at 1100 mg kg^{-1} (4.4×10^7 colony forming units (cfu) kg^{-1}) increased daily feed consumption, egg size, nitrogen and calcium retentions (Nahashon et al., 1996). Yousefi and Karkoodi (2007) reported feed consumption was not affected by the dietary probiotic supplementation. Shareef and Dabbagh (2009) reported that probiotic (*Saccharomyces cervisiae*) supplementation of broilers had significantly increased feed consumption. Results from a study by Babazadeh et al. (2011) indicated that probiotics did not have any significant positive effect on broilers FI, Body Weight (BW) and Feed Conversion Ratio (FCR). Nikpiran et al. (2013) reported that Addition of *Thepax* and *Saccharomyces cerevisiae* significantly increased FI in Japanese quails.

Effects on growth performance

Song et al. (2014) reported significant increase in body weight gain in broilers fed with probiotics *Lactobacillus*, *Bifidobacterium*, coliforms, and *Clostridium* species. Results from Kabir Rahman et al. (2004) indicated that the live weight gains were significantly (P<0.01) higher in birds supplemented with probiotics as compared to the control group at all levels during the period of 2^{nd}, 4^{th}, 5^{th} and 6^{th} weeks of age, both in vaccinated and non-vaccinated birds. Other studies (Jin et al., 1997; Zulkifli et al., 200; Kalavathy et al., 2003; Santos et al., 2005; Apata, 2008 and Ashayerizadeh et al., 2009) demonstrated increased live weight gain in probiotic fed birds. On the other hand, Lan et al. (2003) found higher (P<0.01) weight gains in broilers subjected to two probiotic species. Shareef and Dabbagh (2009) reported that probiotic (*Saccharomyces cervisiae*) supplementation of broilers, at level of 1, 1.5 and 2%, had significantly increased the body weight gain, feed consumption and feed conversion efficiency. Reports (Banday and Risam, 2002) have suggested that probiotic supplementation improved performance of broilers. Nikpiran et al. (2013) reported that *Thepax* and *Saccharomyces cerevisiae* had positive effects on performance of Japanese quails. Zhang and Kim (2014) reported an overall increase in body weight gain in chicken fed with multistrain probiotics compared with that in control group fed basal diet.

Sherief and Sherief (2011) reported that significantly higher body weight is recorded on broiler flocks that received probiotics. Huang et al. (2004) demonstrated that inactivated probiotics, disrupted by a high-pressure homogenizer, have positive effects on the production performance of broiler chickens when used at certain concentrations. Endens et al. (2003) reported that probiotics improved digestion, absorption and availability of nutrition accompanying with positive effects on intestine activity and increasing digestive enzymes. Mansoub (2010) reported significant increase in body weight of broilers fed with *Lactobacillus acidophilus* and *Lactobacillus casei*. Amer and Khan (2011) showed that the supplementation of probiotic (*Lactobacillus acidophilus, Bacillus subtilis, Saccharomyces cerevisiae and Aspergillus oryzae*) indicated significant increase body weight gain after 6 weeks of experiment. However, some studies show that probiotic supplementation doesn't improve chickens' feed intake (Mansoub, 2010; Jin et al., 1998 and Murry et al., 2006), while Timmerman et al. (2006) found inconsistent results, maybe because of type of diet ingredients which can affect probiotic's growth or their metabolites. Yousefi and Karkoodi (2007) found that body weight changes were not significantly different among treatment groups and feed conversion ratio was not affected by the dietary probiotic supplementation.

Effects on egg production and quality

Raka et al. (2014) reported the highest hen day production and egg weight in layers supplemented with Liquid Probiotics Mixed Culture (LPMC) containing two type microorganisms, *Lactobacillus* and *Bacillus* species. Tortuero and Fernandez (1995) reported that at the end of probiotic bacteria mixed culture to maize basal diet improved hen day egg production. Similarly, in barley based diets, addition of probiotic bacteria increased egg size but there were no differences in feed intake feed conversion ratio and egg specific gravity in layers (Tortuero and Fernandez, 1995). Kurtoglu et al. (2004) reported that supplementation probiotic *Bacillus licheniformis* and *Bacillus subtilis* increased egg production and decreased percentages of damaged egg in Brown-Nick layer hybrids.

Daneshyar et al. (2009) reported that the addition of probiotics did not have significant effect on egg production and egg mass but significant effect was recorded on egg weight. The same result was reported by Ramasamy et al. (2008) supplementation of *Lactobacillus* cultures did not influence the egg production of hens throughout the experimental period and no significant difference in egg weight in hens fed with *Lactobacillus acidophilus.* Davis and Anderson (2002) also found no significant improvement in egg production of hens supplemented with Prima Lac, a commercial product containing *Lactobacillus* species. On the other hand, significant improvement in egg production was observed in hens fed with a mixed culture of *Lactobacillus acidophilus*, *Lactobacillus casei* and *Lactobacillus acidophilus* (Haddadin et al., 1996).

Yörük et al. (2004) reported that egg production in Hisex Brown layers fed with probiotics contained *Lactobacillus plantarum*, *Lactobacillus delbrueckii* subsp. *bulgaricus*, *Lactobacillus acidophilus*, *Lactobacillus rhamnosus*, *Bifidobacterium bifidum*, *Streptococcus salivarius* subsp. *thermophilus*, *Enterococcus faecium*, *Aspergillus oryza* and *Candida pintolopesii* showed greater egg production than the group fed with basal diet. Moreover, there were linear increases in egg production with increased supplemental probiotic. Haddadin et al. (1996) reported that egg quality had improved by the addition of a liquid culture of probiotic bacteria to the basal diet. However, the egg weight was significantly greater in *Lactobacillus* Culture fed hens (58.77 gram) from 20 to 68 weeks of age. Addition of probiotic had no significant effect ($P>0.05$) on shell hardness and shell thickness and these were expected which have already been reported (Haddadin et al., 1996 and Mohan et al., 1995). On the other hand, Saadia and Nagla (2010) indicated that significant higher egg production was recorded in Hy-line layers supplemented with probiotic *Saccharomyces cerevisiae.*

Hypocholesterolemic Potential

Mansoub (2010) reported that the cholesterol level of serum significantly decreased in groups supplemented with probiotics in assimilation of cholesterol by *Lactobacillus* compared to control group fed with basal diet. The same study also reported that there is a significant decrease in the serum level of triglycerides between control group and groups treated with *Lactobacillus acidophilus* and *Lactobacillus casei* supplemented in broiler diet in combination with water or alone. Kurtoglu et al. (2004) reported that supplementation probiotic *Bacillus licheniformis* and *Bacillus subtilis* decreased egg yolk cholesterol and serum cholesterol levels in Brown-Nick layer hybrids.

Corcoran et al. (2005) reported that fat digestion rate is linked to the rate of gallbladder acids in digestion latex and subsequently the lipid concentration. *Lactobacillus acidophilus* and *Lactobacillus casei* in diet or water cause a decrease in gallbladder acids in digestion latex and this resulted in a reduction in the ability of fat digestion and therefore decreasing lipid level of blood (Corcoran et al., 2005). *L. acidophilus* can absorb cholesterol in vitro, and this phenomenon can decrease the cholesterol level of medium (Gilliland et al., 1985).

Ashayerizadeh et al. (2011) reported that dietary supplementation with probiotic decrease cholesterol concentration when compared with birds fed basal diet, prebiotic and antibiotic diets. The cholesterol content of eggs produced by probiotic (*Lactobacillus* culture) fed hens was significantly lower by 15.3% and 10.4% when compared to those of the control hens at 24 and 28 weeks of age, respectively (Ramasamy et al., 2008). Mahdavi et al. (2005) also reported that probiotic *Bacillus subtilis* and *Bacillus licheniformis* supplementation reduced the plasma cholesterol and triglyceride significantly. *Saccharomyces cerevisiae* probiotic supplementation has been shown to reduce the cholesterol concentration in egg yolk which was reported by Abdulrahim et al. (1996) and serum concentration in chicken (Mohan et al., 1996). A study by Amer and Khan (2011) showed that the supplementation of probiotic (*Lactobacillus acidophilus, Bacillus subtilis, Saccharomyces cerevisiae* and *Aspergillus oryzae*) indicated significant decrease in serum cholesterol concentration after 6 weeks of experiment with probiotic treatment.

CONCLUSION

Probiotics have a number of beneficial effects in poultry production. According to different studies, provision of probiotics improves feed intake, feed conversation ratio, stimulates growth rate, increases egg production and have hypocholesteronemic effects on poultry products. However, some studies reported no significant effect of feeding probiotics on feed intake, growth performance and egg production. Despite the wide use of probiotics in poultry production, an accurate dosage of administration has yet to be established. It can be mixed into water and feed with different dosages.

Competing interests

The authors have no competing interests to declare.

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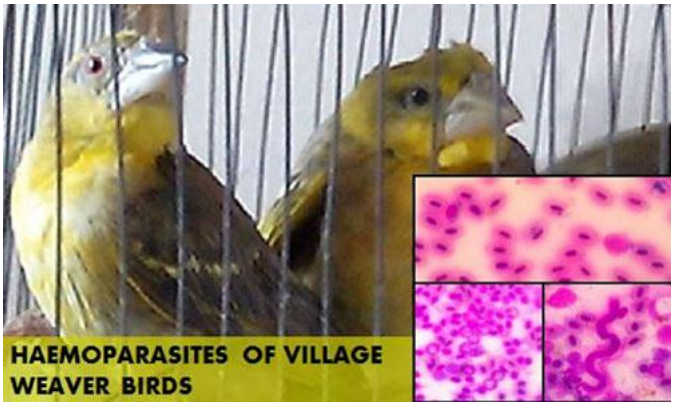

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Pelczar JR, Harley JP, Klein DA (1993). Microbiology: Concepts and Applications. McGraw-Hill Inc., New York, pp. 591-603.
e) Books, containing sections written by different authors:
Kunev M (1979). Pig Fattening. In: A. Alexiev (Editor), Farm Animal Feeding. Vol. III. Feeding of Different Animal Species, Zemizdat, Sofia, p. 233-243 (Bg).
In referring to a personal communication the two words are followed by the year, e.g. (Brown, J. M., personal communication, 1982). In this case initials are given in the text.

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Molar	mol/L	**Mililitre**	ml
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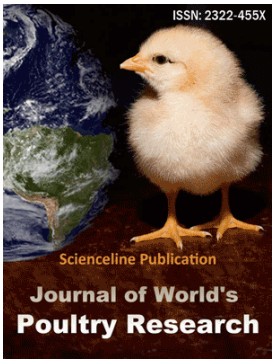

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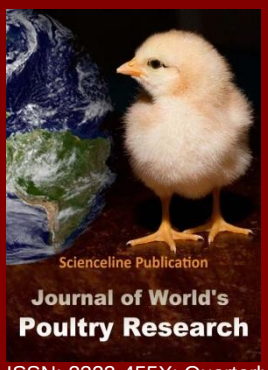

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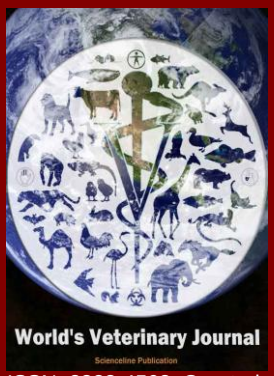

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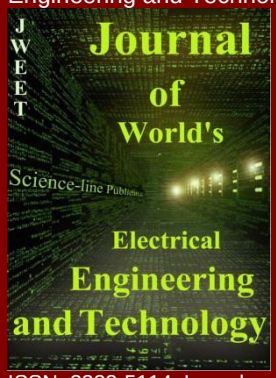

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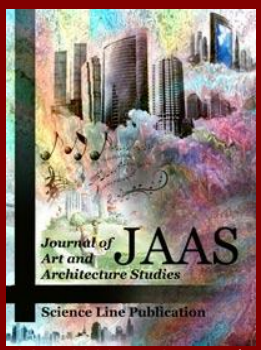

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