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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

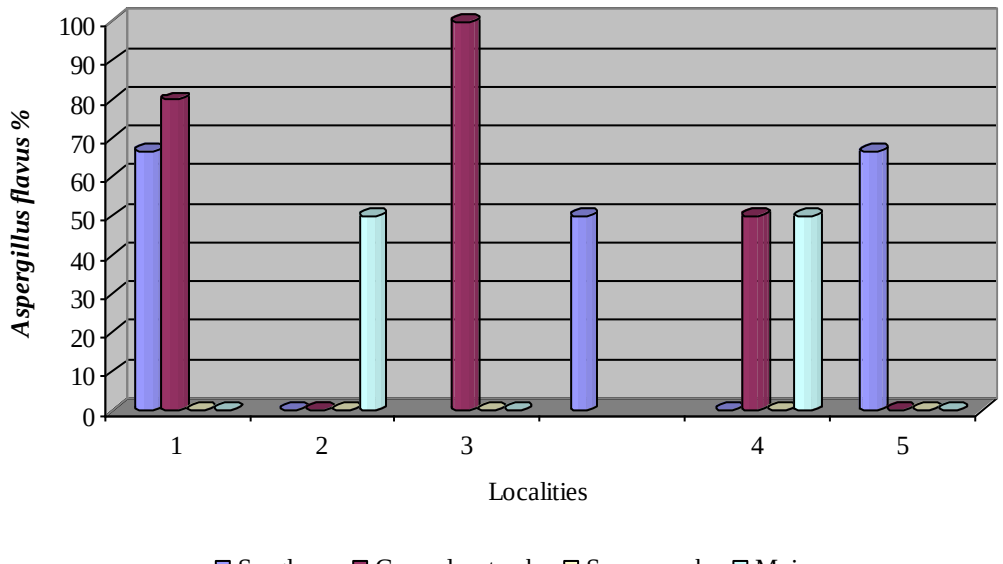

Figure 1. *Aspergillus flavus* contamination in main feed ingredients in poultry farms in different localities of Gezira state, Sudan 2013. (1: South of the Gezira, 2: East of the Gezira, 3: Almanagil, 4: Alkamleen, 5: GreaderMedani).

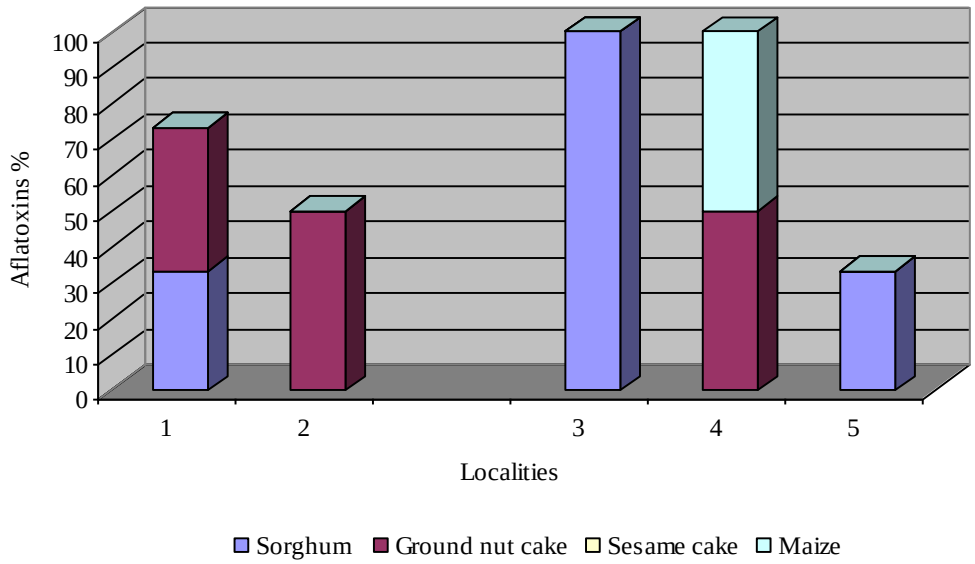

Figure 2. Aflatoxin presence in main feed ingredients in poultry farms in different localities of Gezira State, Sudan, 2010. (1: South of the Gezira, 2: East of the Gezira, 3: Almanagil, 4: Alkamleen, 5: GreaterMedani).

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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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