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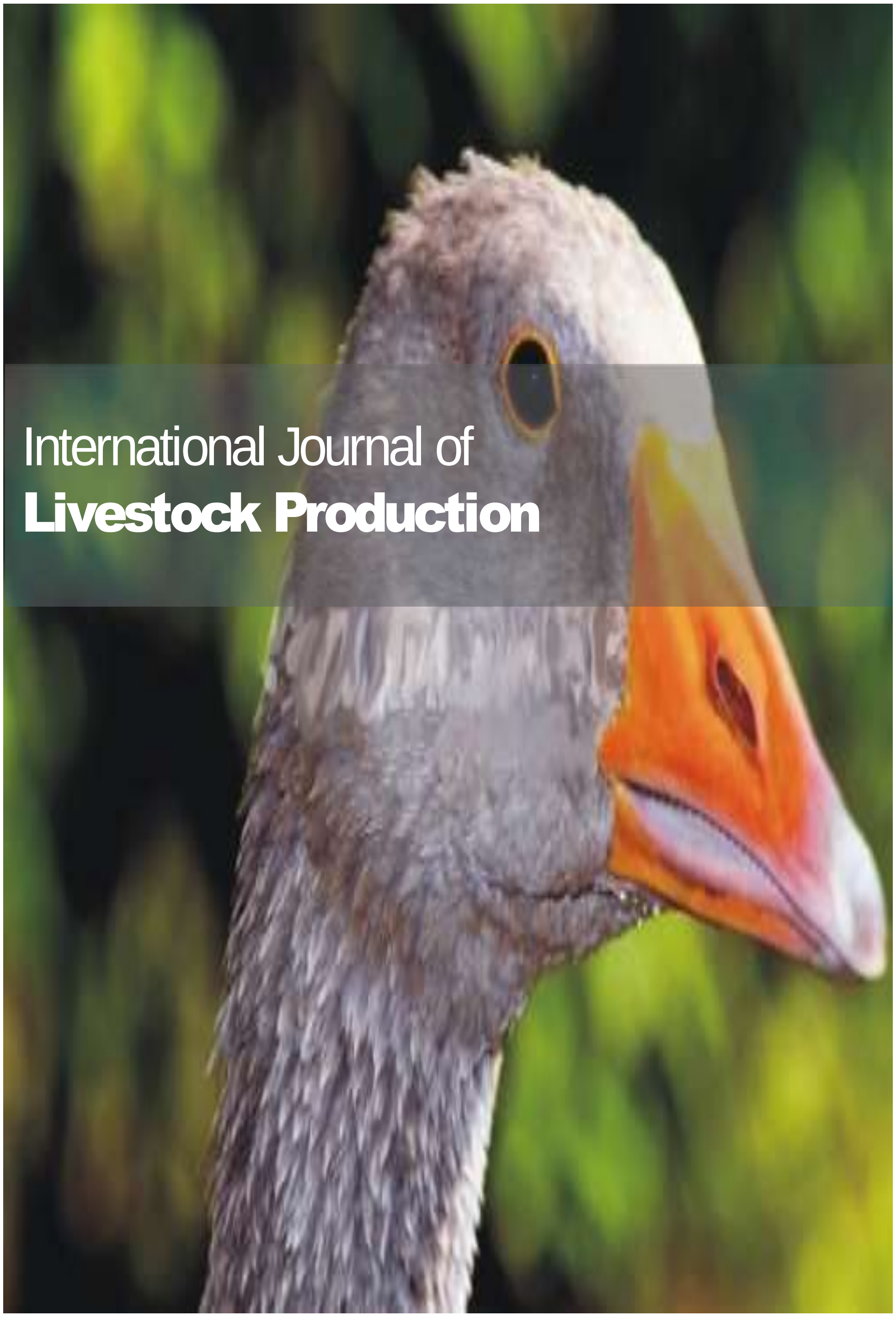

November 2018
ISSN 2141-2448
DOI: 10.5897/IJLP
www.academicjournals.org

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DOI: 10.5897/IJLP2017.0392
Article Number: 23A46B658839
ISSN: 2141-2448

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Full Length Research Paper

Assessment of factors affecting adoption of exotic chicken breed production in North Western Zone of Tigray, Ethiopia

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Received 18 June, 2017; Accepted 12 September, 2017

Exotic chicken breeds were promoted and disseminated in the rural and peri-urban parts of Ethiopia, to improve the productivity of the poultry to increase the income of farmers. The study was conducted to explore the factors affecting adoption of exotic chicken breed in Tselemti and Tahtay Koraro districts of North Western zone of Tigray region, Ethiopia. A multi-stage random sampling technique was followed to select 264 respondents from the six randomly selected Kebelles of the two districts. Primary data were collected using semi-structured interview questionnaire from the respondents. Descriptive statistics and binary logistic regression model were used for analyzing the collected quantitative data. The results of the logit model indicates that family size, sex of the household head, education status of the household head, livestock holding size, extension contact, availability of exotic chicken breed, distance to the nearest market and availability of training on poultry production could play a significant role on the probability of exotic poultry breed adoption. Thus, the dissemination of different exotic chicken breeds needs to be supported with giving training to the farmers before intervention of the technology, extension backup on how to manage and awareness creation on the benefits of exotic chicken breed and giving focus in delivering and making available the chicks of exotic poultry breeds to the farmers.

Key words: Adoption, exotic poultry breed, factors, binary logit model.

INTRODUCTION

Family poultry is important for food security, religious reasons and poverty alleviation in developing countries including Ethiopia.

Poultry production is the most suitable technology that is practiced in every rural and peri-urban parts of Ethiopia which requires a small land and capital for investing (Tadelle et al., 2003). In Ethiopia there is no any cultural taboo on egg and chicken meat consumption (Aklilu et

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al., 2007). The type of poultry reared in Ethiopia is chicken (Solomon, 2008; Tadelle et al., 2003).

Ethiopia there is no any cultural taboo on egg and chicken meat consumption (Aklilu et al., 2007). The type of poultry reared in Ethiopia is chicken (Solomon, 2008; Tadelle et al., 2003).

Chicken meat and egg production in Ethiopia in 2015 was 49,000 tonnes and 419 million, respectively (LMP, 2015). Ethiopian livestock Master Plan Roadmaps for growth and transformation has estimated that by the year 2020, poultry annual chicken meat and egg production in Ethiopia would rise to 164,000 tonnes and 3.9 billion, respectively, and increasing the share of chicken meat consumption to total meat consumption from the 4% in 2015 to 27% by 2030, by distributing improved chicken breeds (LMP, 2015).

In Ethiopia at national level, poultry population is estimated to be 56.87 million (CSA, 2015). Of these in breed type, 95.86, 2.79 and 1.35% of the total poultry are indigenous, hybrid and exotic, respectively. The total chicken population of Tigray region is estimated to be 6.2 million, which accounts for 10.4% of the national chicken population and contributing about 10.8% of the total national egg production (CSA, 2015).

To improve the chicken production so as to increase the chicken contribution to income and dietary diversity of the household, Ministry of Agriculture and Rural Development of the country have been multiplied and disseminated several exotic chicken breeds to the farmers over the last 50 years in different parts of the country (Solomon, 2008).

North western zone of Tigray is one of the six zones of Tigray region. The zone is potential in producing poultry having 2,365,451 chickens which accounts for 38.2% of the chicken population of the region (CSA, 2015). Similarly to other parts of Ethiopia, in Tigray particularly in north western zone of Tigray, great attempt has been executed to improve the chicken production by introducing and distributing exotic chicken breeds for the last 15 years (OoFED, 2016).

Bovans Brown, Rhode Island Red and Koekoek are the most common exotic poultry breed types disseminated to the farmers in the study area. The distribution of these exotic poultry breed had been done through the collaborative efforts of the governmental and non-governmental organizations. The breeds are distributed to the beneficiaries when they are two months old (OoARD, 2016 Even though a number of exotic chicken are distributed annually to the farmers, adoption of the exotic chicken breed at country level is very low. So far, the total poultry production at the country level (95.86%) is endowed with local breed of scavenging types (CSA, 2015). But, the output (egg and meat) of the local breed is low when compared with exotic chickens (Alganesh et al., 2003).

The reasons for non-adoption of the improved chicken breed is due its hindrance by a set of factors including sub-optimal management, lack of supplementary feed and high mortality rate due to diseases and predators (Tadelle et al., 2003; Teklewold et al., 2006).

However, the authors are not aware of any study conducted on the factors affecting adoption of exotic chicken breed in Tigray region. Thus, the purpose of this study was to investigate the factors that influence the adoption of exotic poultry breeds in the study areas.

MATERIALS AND METHODS

Description of the study area

This study was carried out in six selected villages from two Woredas of the north western zone of
Tigray. Tigray regional state is located in the northern part of Ethiopia. North western zone is one of the six administrative zones in Tigray Region which is located at 304 km west of Mekelle and 1087 km from Addis Ababa. The zone is known in its livestock production; particularly poultry production. The zone has 1,858,256 cattle, 175,587 sheep 1,971,601 goats and 2,365,451 chickens (CSA, 2015). Tselemti and Tahtay Koraro districts of the zone were selected for the study. Tselemti district is found at 1172 km from Addis Ababa, 389 km west of Mekelle and 85 km south of Shire; while, Tahtay Koraro district is located at 1087 km from Addis Ababa and 304 km west of Mekelle (Figure 1).

Sampling procedures

In this study, multi stage sampling procedure was employed in selecting the respondent households.

In the first stage, Tselemti and Tahtay Koraro districts were selected purposively based on their potential exotic poultry breed production from north western zone of Tigray, of the eight districts of the zone. Then, among the identified Kebelles, three Kebelles from each of the two Woredas were selected using simple random sampling method. Out of the 132 farm households from each of the two Woredas, a total of 264 sample households were selected for the study. The number of sample respondents from each of the selected Kebelles, the adopters and non-adopters were identified based on the probability proportionate on the sample size in each of the selected Woredas. Finally, respondents were selected using systematic random sampling from both strata (adopters and non-adopters) in each Kebelles. Adopters are those producers who are involved in exotic poultry production either in pure or cross breed forms during the survey year and given a value of 1, whereas, non-adopters are those producers of poultry who have not kept exotic chicken before and given a value of 0. The total sample size was determined by using Kothari (2004) formula as follows:

$$n = \frac{Z^2.p.q.N}{e^2(N-1)+Z^2.p.q}$$

where n = sample size determined from the total household, N = total poultry producer household of the two Woredas (29907), Z = confidence level, p = (0.5), = 1- p, e = allowable error in the study (e=6%). Accordingly, the number of respondents in each Kebelles/Villages is shown in Table 1.

Sources and methods of data collection

Primary and secondary data were collected and used for this study.
Primary data were collected from sample respondents through

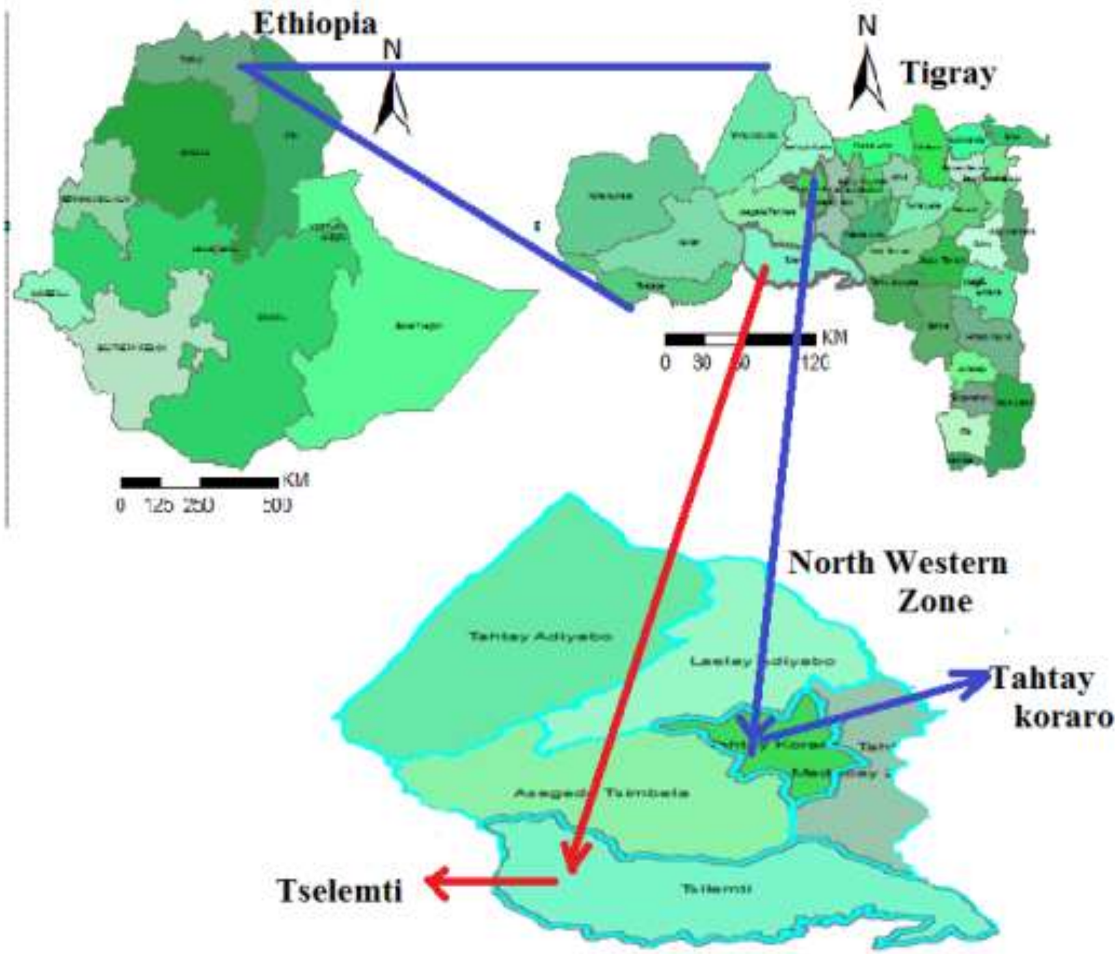

Figure 1. Map of the study area.

Table 1. The number of households selected from each Kebelles.

S/N	Woreda	Kebelle	Total number of households in the sampled Kebelles			Sample households selected		
			Adopter	Non-adopter	Total	Adopter	Non-adopter	Total
1	Tselemti	Wuhdet	550	830	1380	21	31	52
		Medhanalem	625	739	1364	23	28	51
		Mai-ayni	324	452	776	12	17	29
		Sub total	1499	2051	3520	56	76	132
2	Tahtay Koraro	Selam	458	687	1145	18	26	44
		Adigdad	550	790	1340	21	30	51
		Haftom	387	578	965	15	22	37
		Sub total	1395	2055	3450	54	78	154
		Grand total	2894	4076	6970	110	154	264

Source: Computed from Secondary Data, 2016.

interview using semi-structured questionnaire. The survey was conducted from October to December 2016 through hiring enumerators. Secondary data were gathered from different relevant sources such as reports of Woreda Office of Agriculture Rural

Table 2. Value of the continuous explanatory variable between adopters and non-adopters.

S/N	Variable	Adopter (n=110) Mean (SD)	Non-adopter (n=154) Mean (SD)	t-test	p-value
1	Age of the household head	41.28 (8.78)	47.64 (7.87)	7.32***	0.000
2	Family size	6.55 (1.12)	4.51 (0.94)	2.57***	0.000
3	Poultry farming experience	11.68 (7.80)	13.89 (8.74)	2.30^{NS}	0.221
4	Livestock holding	4.3 (3.92)	7.82 (4.69)	6.69***	0.000
5	Market distance	7.29 (15.68)	9.22 (25.09)	10.86***	0.000

Sources: Computed from Own Survey, 2016. *** Significant at 1% level of significance and NS = Not Significant, SD refers to standard divisions

Development, Central Statistical Authority, Research Center, different published and unpublished documents, research studies, websites, etc.

Method of data analysis

Based on the objective of the study, appropriate techniques of analysis such as descriptive and inferential statistics (t-test) were used to see the difference between adopter and non-adopter. Binary logit model was used to identify the factors affecting adoption of exotic poultry breed in the study area. Before running the logit model, all the hypothesized explanatory variables were checked for the existence of multi-collinearity problem. Variance Inflation Factor (VIF) for association among the continuous explanatory variables and contingency coefficients for dummy variables were employed in this study to detect the existence of multi-collinearity. As a rule of thumb, if the VIF of a continuous variable exceeds 10, that variable is said to be highly collinear. For dummy variables, if the value of contingency coefficient is greater than 0.75, the variable is said to be collinear (Gujarati, 2004).

RESULT AND DISCUSSION

Descriptive statistics

The mean age of the respondents is 44.46 years. The average age of adopters and non-adopters are 41.28 and 47.64, respectively. This might indicate that young farmers were becoming interested in trying and adopting exotic chicken breed than aged farmers (Table 2). The average family size of the sample households is 5.5 persons. The average family size for adopters and non-adopter are 6.5 and 4.5 persons, respectively. The household that have large family size were better in adopting the chicken technology. This could show that having large family size enables farmers to manage their exotic poultry in a well manner. The average livestock holding in Tropical livestock unit (TLU) of the adopters and non-adopters sample households are 4.3 and 7.82 TLU, respectively. However, the average distance taken for the household to sale their chicken product from their residence to the nearest market place is 7.29 and 9.22 km, respectively, for adopters and non-adopters.

Econometric analysis

The chi-square goodness-of-fit test statistics of the model show that the model fits the data at 1% level of significance. This shows that the explanatory variables included in the model are able to explain the farm households' decisions to the adoption of exotic poultry breed. The model results show that the logistic regression model correctly predicted 97.7% of the sample households. The sensitivity (correctly predicted of exotic poultry users) and specificity (correctly predicted non-users) of the logit model are 98.2 and 97.4%, respectively. Hence, the model predicts both groups accurately. Based on the model results, livestock holding and market distance were found to have a negative sign, while the remaining variables; education, sex, family size, extension contact, access to exotic poultry breeds and participating in training have a positive sign (Table 3). The effect of the model estimates was interpreted in relation to the significant explanatory variables in the model according to the following:

Sex of the household head

The variable sex was found to have a significant and positive influence on adoption of exotic poultry breeds. The result is in line with that of the expectation. The model result shows that all other factors were kept constant, the probability of adopting exotic poultry increases by a factor of 50.087 for male headed households. The positive sign implies that the male headed households were better in adopting the exotic poultry breeds than female headed households. This could be due to the reason that male headed households have better financial capacity to buy exotic poultry breeds, and have better information access about the technology than their counterpart. Hence, this can encourage male headed households to adopt exotic poultry breeds. The result is similar with the findings of Justus (2012) which justified that male headed farmers were better in adopting chickens.

Table 3. The maximum likelihood estimation of the binary logit model.

S/N	Variable	Coefficient	P-value	Odds ratio
1	Age of the household head	-0.033	0.614	0.967
2	Sex of the household head	3.914**	0.018	50.087
3	Education status of the household head	3.070**	0.015	21.540
4	Family size	2.440***	0.000	11.473
5	Poultry farming experience	0.118	0.115	1.125
6	Off-farm income	1.318	0.299	3.736
7	Livestock holding	-0.402***	0.008	0.669
8	Access to exotic chicken breed	2.380*	0.096	10.803
9	Access to vaccination service	0.545	0.906	1.724
10	Access to credit	0.107	0.944	1.113
11	Market distance	-0.072*	0.052	0.931
12	Extension contact	3.143**	0.029	23.166
13	Participation in training	4.062***	0.003	58.114
14	Constant	19.06	0.010	0.000
Chi-square		324.196		
-2log likelihood		34.418		
Over all prediction		97.7		
Sensitivity		98.2		
Specificity		97.4		
Number of cases		264		

Education status of the household head

As expected, education status of household heads is found to have a significant and positive relationship with the probability of adoption of exotic poultry breeds at the 5% level of significance. The logit model result indicates that other factors were kept constant, if the household heads were literate, the odds-ratio in favor of adopting exotic poultry breed increases by a factor of 21.54 than those who were illiterate. This may be due to the fact that educated farmers are more analytical, have access to information and observe the advantages of new technologies easily influencing them to adopt the new technologies. The result agrees with the findings of Ermias et al. (2015), justifying that the literate farmer was more likely to adopt village poultry technology packages than the illiterate farmers.

Family size

Family size is an indication of labor availability. As expected, it had a positive sign influence on adoption of exotic poultry breeds. The result of the model indicates that other factors kept were constant, as the family size increases by one unit, adoption of exotic poultry breed increases by a factor of 11.473. This might be due to the reason that having a large family enables a given household to manage its poultry properly, and have no problem to sale chicken products. The result of this study is compatible with the finding of Dehinenet et al. (2014) and Teklewold et al. (2006) which shows that having large family size affects positively for adoption of improved dairy and exotic poultry technologies, respectively.

Livestock holding

Livestock holding is hypothesized to have a negative relationship with the adoption of exotic poultry breeds. It was influenced as expected. The result of the odds-ratio shows that other factors were kept constant, as livestock holding of a household increased by 1 TLU, the logs of odds-ratio in favor of household adoption of exotic poultry breeds decreased by a factor of 0.669. This result shows that those farmers with large number of livestock are less likely to adopt exotic poultry breed than those who own small number of livestock. This is due to the fact that as a farmer own large number of livestock in TLU, he/she could generate enough cash from the livestock and their trend to adopt exotic poultry breeds becomes lower. The reason could be due to the reason that the focus of farmers tend to produce other animals rather than poultry. The result of this study is consistent with the findings of Wondmeneh et al. (2014) which revealed that holding of large livestock affects adoption of exotic poultry breeds significantly and negatively.

Extension contact

As hypothesized, farmers' contact with extension agents positively influenced the adoption of exotic poultry at 5% level of significance. Other factors were kept constant, the odds-ratio in favor of adopting exotic poultry breed increases by a factor of 23.166 for the farmers who had extension contact than those who did not have extension contact. This implies that farmers who have contact with extension agents become aware of and informed about new technologies in relation to poultry production packages becoming more effective than the farmers who do not have extension contact. Hence, farmers having contact with extension agents could have a higher probability of adopting exotic poultry breeds than those who have not. The finding of the study is consistent with the findings of Ermias et al. (2015) which suggest that contact of extension agents with the farmers affect the adoption significantly and positively.

Participation in training

Farmers' participation in training organized in relation to poultry production influenced the adoption of exotic poultry breeds significantly and positively, as expected, at less than 1% significance level. The logit model result indicates that, keeping other factors constant, if a household participates in training, the odds-ratio in favor of the household adoption of exotic poultry breed increases by a factor of 58.114. This indicates that farmers participating in training acquire sufficient knowledge and skill about the use of exotic poultry breeds which helps respondents to likely to adopt the new breeds. The result of this study is in agreement with the findings of Sisay et al. (2013) and Dehinenet et al. (2014) which justified that participation of farmers in training had a positive and significant influence on the probability of adoption of modern bee hive and dairy technologies, respectively.

Market distance

As expected, the distance of farmers' residence from the nearest market center is significantly and negatively associated with exotic poultry adoption decision at 10% level of significance. The result of the odds-ratio indicates that, other factors being constant, as the distance of the farmer's residence from the nearest market center increases by 1 km, the probability of farmers to adopt exotic poultry breed decreases by a factor of 0.931. This is due to the fact that as the farmers reside far from the nearest market they face high transportation cost for selling their output, and also have low market information which can reduce farmers' decision to adopt exotic poultry breeds. In line with this study's findings, the findings by Simegnew et al. (2015) revealed the distance to market to significantly and negatively affect the adoption of exotic poultry breeds.

Access to exotic chicken breeds

The logit model result indicates that the variable access to exotic poultry breeds had a significant and positive influence on the likelihood of adopting exotic poultry breeds. By keeping other factors constant, the odds-ratio in favor of adopting exotic poultry breed increases by a factor of 10.803 for the farmers who have access of exotic poultry breed than those who did not have access. This indicates that if farmers have access to exotic poultry breeds, the probability of adopting exotic poultry breeds also increases. This study is consistent with the findings of Wondmeneh et al. (2014) which revealed that access of exotic poultry breed was one of the factors that influence the probability of adopting exotic poultry breed.

CONCLUSIONS AND RECOMMENDATIONS

This study indicates that access to exotic poultry breed, family size, extension services, training on poultry, access to market distance, sex of household head, education status of household head and the size of holding livestock played a significant roles on the probability of exotic poultry technology adoption in the study area. Thus, this study emphasizes that introduction and dissemination of different exotic poultry breeds need to be supported with a continuous training and extension backup on how to manage and create awareness on the benefits of producing exotic chicken breed as well. Furthermore, focus should be given in delivering and making available the chicks of exotic poultry breeds to the farmers.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Tigray Agricultural Research Institute for the research grant. Special thanks also go to agricultural experts and respondent farmers of Tselemti and Tahtay Koraro districts for their kind cooperation for the study.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Vol. 9(11), pp. 300-307, November 2018
DOI: 10.5897/IJLP2018.0450
Article Number: 86DD49A58841
ISSN: 2141-2448

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Full Length Research Paper

Assessment on consumption and marketing system of chickens in Gena Bossa district, south Ethiopia

Matawork Milkias

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Received 23 January, 2018; Accepted 9 August, 2018

This study was conducted in Gena Bossa district on assessment of consumption and marketing of chickens with the objectives of assessing chicken meat and egg consumption and marketing system of chickens. Random sampling method was used to select 138 households for interview. About 55.1% of chickens were owned by wife and the rest of flocks were owned by husband, boys and girls. Almost all of the farm activities were conducted by women especially cleaning poultry house, feeding and watering of chickens. About 40.6% of respondents provide half a day to care chickens. Chicken meat and egg consumption were connected with holidays. Farmers consume chicken meat 3.64 times per year and they consume egg 2.22 times per month. There were no formal market channel for live chickens and egg marketing. Market fluctuation of chickens and eggs occur during holidays. Unstable price, demand seasonality, lack of market places, poor infrastructure and lack of market information were common factors affecting live chicken and egg marketing in the study area. In summary, this result recommended that government should organize production of chickens with marketing channel.

Key words: Chicken, consumption, marketing, Gena Bossa.

INTRODUCTION

Poultry particularly chickens are the most numerous and widely raised livestock species in the world (FAO, 2012). In Africa, almost every homestead keeps some poultry for mainly home consumption and cash sales (Dwinger and Unger, 2004). In most African countries, the rural chicken population accounts for more than 60% of the total national chicken population (Kitalyi, 1998). In Ethiopia chickens are the most widespread and almost every rural family owns chickens, which provide a valuable source of family protein and income (Tadelle et al., 2003). The Ethiopia poultry population is estimated to be about 60.5 million. About 83.5, 7.1 and 9.4% meat and egg product comes from indigenous, hybrid and exotic breeds of poultry (CSA, 2016).

Poultry production systems in Ethiopia show a clear distinction between traditional, low input systems and modern production systems using relatively advanced technology (Alemu, 1995). There is also a third upcoming "small scale" intensive system with small number of birds (from 50 to 500) as an urban and per-urban household income source using exotic birds and relatively improved feeding, housing and health care (Alemu and Tadelle, 1997). The most dominant chicken types reared in Ethiopia are local ecotypes, which show a large variation in body position, plumage colour, comb type and productivity (Halima, 2007). However, the economic

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contribution of the sector is not still proportional to the huge chicken numbers, attributed to the presence of many productions, reproduction and infrastructural constraints (Aberra, 2000).

Village poultry is kept with minimal input of resources and is considered by most smallholders as supplementary to the main livelihood activities. The chickens scavenge to find feed and are rarely provided supplementary feed to increase production of egg and meat. Sheds, if provided, are made of local materials. Poultry keepers lose many chickens as a result of diseases and exposure to predators, but little attention is paid to the health and protection of predators. The chickens are mainly indigenous, sometimes mixed with foreign breeds and cross breeds. Poultry contributes household income and provides access to high-quality protein, which is generally in short supply.

Poultry products offer affordable quality animal protein sources for the smallholder farm households. Rural households consume a very limited quantity of poultry products. They rank cash income as the primary purpose of village chicken production. Poultry consumption is moreover closely associated with wealth status. Chickens are not a daily food even for a better-off household. Chickens are consumed mostly during holidays. In general, poultry consumption accounts or less than 1% of the total annual food needs of farm households (Bush, 2006).

Despite their low productivity, indigenous chicken are known to possess desirable characteristics such as thermo-tolerance, resistance to some diseases, good egg and meat flavor, presence of hard egg shells, high fertility and hatchability as well as high dressing percentage (Aberra, 2000). There were highest numbers of chickens reared in Ethiopia, particularly in Gena Bossa district of South Ethiopia. But consumption and marketing of chickens and its products were not proportional to its number in the study area. Consumption and marketing system of chickens and its products were not documented in Gena Bossa district. This being the case, the major objectives of research was to assess chicken consumption and marketing systems in the study area with the following specific objectives:

(i) To assess chicken meat and egg consumption in the study area
(ii) To assess chicken and its product marketing systems in the study area
(iii) To assess labor allocation and owner ship of chickens in Gena Bossa district

MATERIALS AND METHODS

Description of the study area

The study was conducted in Gena Bossa district of Dawuro Zone. Karawo is the main town of the district which is located at about 508 km south west of Addis Ababa across Shashemene and Wolayita, 303 km from Hawassa Town of SNNPR and 192 km from Jimma. There are 19, 159 households in the study area. The annual mean temperature ranges from 16.1 to 28°C. The rainfall is a bimodal type: the short rainy season is between (February to March) and the long rainy season between (May to September). The average annual rainfall ranges from 500 m to 1,200 mm.

Selection of study households

Random sampling methods were used to study population those rears chickens. Based on the number of chicken population and its representativeness six kebeles were selected. The total of 138 households was selected to carry out the survey.

Data collection methods

Questionnaire survey

The data were collected by using both primary and secondary source of data. The primary data were collected by using questionnaire and direct observation. The parameters like consumption of chicken and its products, marketing systems, labor allocation and owner ship of chickens were gathered by using questionnaire.

Data management and analysis

Descriptive statistics such as percentage, mean and frequency were calculated and all survey data was analyzed by using SPSS Version 20. Qualitative and quantitative data sets were analyzed by using appropriate statistical analysis procedures. The simple descriptive statistics (mean, SE) for numerical survey data were calculated by SPSS.

RESULTS AND DISCUSSION

Flock ownership

Ownership of chickens in the study area was shown in Figure 1. According to the survey, 55.1% of chickens were owned by women in the Gena Bossa district. The rest 40.6, 2.2 and 2.2% of chickens were owned by husbands, boys and girls, respectively. This result was similar to the findings of Tadelle et al. (2003) in the central highlands of Ethiopia which reported as women owned and manage birds and controlled the cash generated from the sale of birds. Findings confirmed that women owned most chicken flocks and that income generated from chicken production belongs to them (Pederson et al., 2001). Chicken were the wealth of women in three agro-ecological zones of Ethiopia and higher number (51.4%) of women were the owner of chickens (Goraga et al., 2016). This result was also similar to Getachew et al. (2015) who reported that most chickens are owned and managed by women and men not interested to raise chicken because they considered it as a side business practiced by women to support family income. Ownership of chickens was dominated by women (77.5 and 70%) while ownership of children

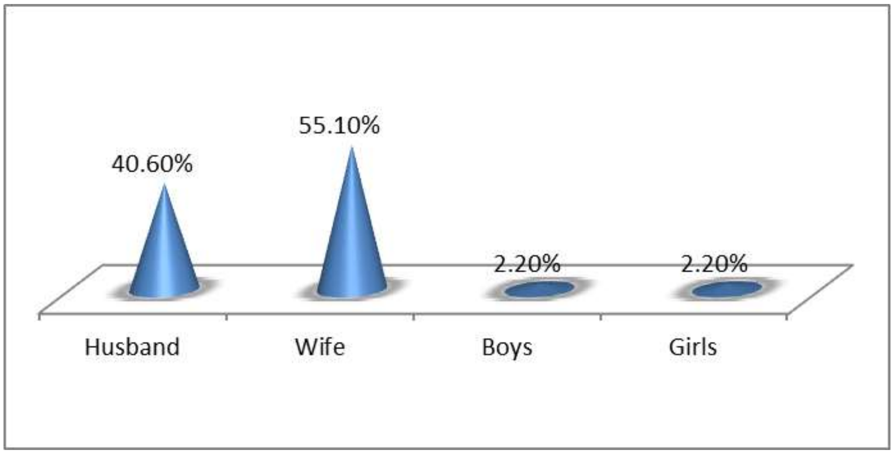

Figure 1. Ownership of chickens in Gena Bossa district.

Table 1. Labor allocation for chicken production.

Farm activities	Men	Women	Boys	Girls
Chickens house construction (%)	62.3	3.6	34.1	-
Chickens house cleaning (%)	-	81.2	-	18.8
Feeding chickens (%)	-	78.3	5.1	16.7
Watering of chickens (%)	0.7	71	7.2	21
Slaughtering chickens (%)	73.2	-	26.8	-
Treating sick chickens (%)	53.6	42.8	3.6	-
Making decision (selling, buying, gift) (%)	58.7	39.1	2.2	-
Selling eggs (%)	-	92	3.6	4.3
Selling live birds (%)	4.3	87.7	2.9	5.1

accounted for 22.5 and 30% of the respondents in lowland and midland agro-ecologies of central Tigray, respectively (Gelila et al., 2016). This result dis-agrees with Meseret (2010) report in Gomma woreda about 96.7% of chicken was owned by women.

Labor allocation for chicken production

Most of chickens' farm activities were conducted by women in the study area (Table 1). House construction was performed by men (62.3%), women (3.6%) and boys (34.1%). Most of farm activities like cleaning poultry house, feeding chickens and watering chickens were performed by women and girls. Slaughtering were the activities which was given for husband and boys only. Most of the time decisions for selling, buying and providing gift were performed by both men and women. Selling eggs and chickens were mainly performed by women. Similarly, Tadelle and Ogle (2001) indicated that in Ethiopia management of chickens was fully in the domain of women whereas decision making regarding control and access to resources varies considerably. This result was also similar to Gelila et al. (2016) in central Tigray, except for the construction of chicken house and treatment of sick chickens women took the major share in management activities related to poultry production. Also rural women accomplished 47.9 to 77.6% of farm activities, except chicken house construction which was mainly (63%) done by rural men and there was a clear difference in task sharing among the different family members; chicken ownership and management were dominated by rural women indicating that village chicken are the property of rural women (Goraga et al., 2016). Mapiye et al. (2005) also reported that women, in Rushinga district of Zimbabwe, were dominated in most of the activities on village chicken production like; feeding (37.7%), watering (51.2%) and cleaning of bird's house (37.2%) where as men were dominant in shelter constructions (60%) and treatment of chickens (40%).

Time given for rearing chickens

The survey data calculated for time given to kept chickens per day were showed in Table 2. According to

Table 2. Time given to kept chickens in the study area.

Time given to kept chickens	Frequency	Percentage
Half a day	56	40.6
A quarter of day	33	23.9
Hours on a day	26	18.8
No times spent	23	16.7

Table 3. chicken meat and egg consumption in the study area.

Consumption	Mean	SE
Household egg consumption per month	2.22	0.082
Household meat consumption per year	3.64	0.112

the result 40.6% of the respondents gave half a day to manage their chickens per day. Other farmers gave a quarter of day, hours on a day and no times spent which requires 23.9, 18.8 and 16.7%, respectively.

Chicken meat and egg consumption

Most farmers consume chicken meat at the time of holiday's especially Christian festivals like Easter. But there were no any cultural/religious taboos against consumption of chicken meat and egg in the study area. According to the survey, producers consume chicken meat 3.64 times per year. About 80% of the respondents consume poultry meat 1-2 times a year indicating egg consumption is comparatively affordable than poultry meat from the point of view of purchasing power since there seems to be no taboos connected to the consumption of poultry and poultry product (Meseret, 2010). Average consumption of chicken per household per year in lowland agro-ecology of central Tigray was 5.4 and 4.4 chickens in male and female headed households while in midland agro-ecology 3.9 and 2.9 chickens in male and female headed households, respectively (Gelila et al., 2016). This result is lower than the value 5.9, annual consumption of chickens per household in Southern Ethiopia (Mekonnen, 2007). Consumption of poultry products is more common in urban than in rural areas. Poultry consumption is commonly high during holiday periods. This result was similar to Moges et al. (2010a) report in Bure district 78% of village chicken owners consumes chicken only during religious/cultural holidays, 20.3% consumes every time when needed/available and only 0.7% reported that they never eat chicken. The national poultry meat consumption is estimated, on an average to be 69,000 tons per annum (ILRI, 2000). This implies they eat at holidays for cerebrations. Also producers in the study area consume eggs 2.22 times per months as shown in Table 3. This implies farmers' sale chickens and eggs rather than consuming in the house. This result was comparable to Gelila et al. (2016) report in central Tigray annual average egg consumption of the households in lowland agro-ecological zones was 39.4 and 44.4 eggs in male and female headed households, respectively and in midland agro-ecology 33.6 and 35.8 eggs in male and female headed households, respectively. Consumption of chicken in present study was higher than Meseret (2010) report in Gomma woreda about 94% of the respondent consume eggs 1-6 times a year whereas as 4% of the respondents do not consume eggs at all.

Marketing systems of chickens and its products

Characteristics of poultry and egg markets

Poultry products in most developing countries, especially in Africa, are still expensive. The marketing system is generally informal and poorly developed. Unlike eggs and meat from commercial hybrid birds (derived from imported stock), local consumers generally prefer those from indigenous stocks. Village poultry producers, consumers and retailers are the main actors involved in poultry and egg marketing in Gena Bossa district. Marketing of poultry and eggs is practiced in various places especially in local and urban markets.

Poultry marketing

All producers those participated on survey were practicing marketing their chickens as well as eggs. There were various places for marketing in Gena Bossa district. There were three major urban markets in the district namely Sunday market at Woldehane, Wednesday market at Angela and Thursday market at Karawo. Producers travel for marketing poultry and eggs

Table 4. Reasons for selling live birds in the study area.

Reason for selling chickens	Frequency	Percentage
Specific weight gain/age of birds	64	48.5
Personal money requirements	55	41.7
During holydays and festivals	13	9.8

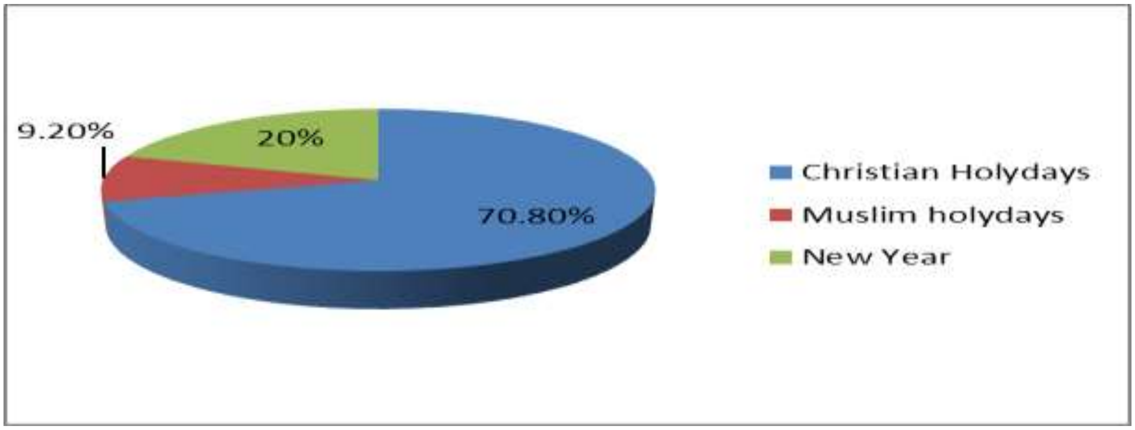

Figure 2. Times of live chicken market fluctuation occurring in the study area.

on average 4.56 km to reach marketing places. Also they sell products at local market as well as farm gate. Backyard poultry owners were selling their birds at their own doorstep, to village market, to local shopkeeper and middleman in Bhandara district of India (Khandait et al., 2011). The major reasons that producers often sale their poultry were when chickens reach specific weight gain per age of bird (48.5%), personal money requirement of the farmers (41.7%) and during holydays and festivals to fulfill income requirements for ceremony of holyday (9.8%) as shown in Table 4. This result was in line with Desalew (2012) funding in east Shewa 73.3% of respondents sale poultry for personal money requirements, and the rest 24.4 and 23.3% of producers' sale their chickens during festivals and holydays in Ada'a and Lume districts, respectively. Farmers sell their chicken mostly when there is an instant cash need in the house (65.6%), when there is disease outbreak to occurs (24.4%) and during the major crop planting seasons (10%) usually occurred from the beginning of the main rainy season at Dale, Wonsho and Loka Abaya weredas of southern Ethiopia (Mekonnen, 2007).

There were market fluctuations of live birds at different time in the study area. The main time at which market fluctuation occurs in the study area were at the time of holydays. The major holydays in which market fluctuation of poultry exist were Christian holydays (70.8%), Muslim holydays (9.2%) and at New Year (20%) as shown in Figure 2. The demand of poultry decreases during fasting period for Orthodox Christians and demand increase during holiday festivities (Getachew et al., 2015). The price of live chickens is affected by seasonal supply and demand especially during holidays and fasting months (Samson and Endalew, 2010).There were also fluctuation of chicken marketing occurs at rain season due to breaking out of diseases in the study area.

There were variations of price on live chickens in market at different time. Laying hens have highest price (44.45±0.83 birr) than pullets (30.9±0.63 birr) in the market. This result was higher than Assefa (2007) reported in which the price of matured cocks and hens were 21.5 (30) and 13.4 (30) birr, respectively. The main determinates of chickens price in the market were feather color, comb type, shank color, body weight and sex of birds which shown in Figure 3. This result was in line with Addisu et al. (2013) report in north Wollo price of live chicken was determined based on body weight (41.83%), combination of comb type and plumage colour (32.35%) and plumage colour (25.82%). There were a lot of problems affecting chicken market in the study area as shown in Table 5. Major factors that affects live chicken market in the study area were unstable bird price, poor sales (demand seasonality), lack of market place, poor infrastructure (road, market, etc.) and lack of marketing information in the study area. Most of farmers could not have market information for their chicken in the district to increase farmer's income level. More than half of the respondents (65%) do not have any information about the price of the chicken before they went to markets in Dale, Wonsho and Loka Abaya weredas of southern Ethiopia

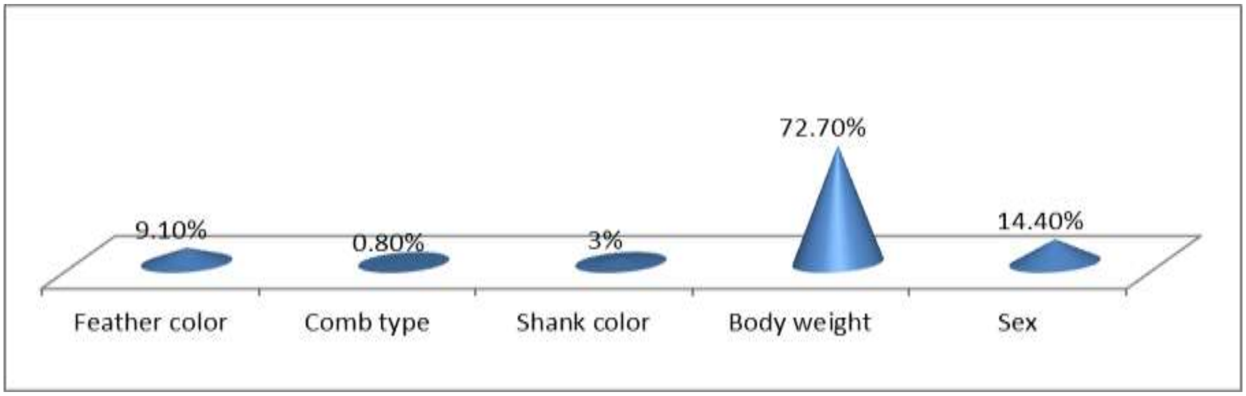

Figure 3. Determinant factors of chicken market price.

Table 5. Problems related to live chicken market in the Gena Bossa district.

Problems	Frequency	Percentage
Unstable bird price	50	37.9
Poor sales (demand seasonality)	51	38.6
Lack of market places	10	7.6
Poor infrastructure (road, market, etc.)	16	12.1
Lack of market information	4	3
Others	1	0.8

Table 6. Regular clients of egg in the study area.

Regular clients	Frequency	Percentage
Village collector/neighbors	50	37.9
Collectors in the market	50	37.9
Consumers	32	24.2

(Mekonnen, 2007).

Poultry egg marketing

Poultry producers were familiar to egg marketing in the study area. Women and children are responsible for egg marketing. The major egg marketing places in the district were local market, farm gate and urban markets. Transportation of eggs for market was very difficult in the study area due to lack of standard road and transportation materials. Farmers travel for marketing eggs on average 4.56 km to reach marketing places.

The egg marketing channel is more or less similar to that of chicken. Eggs are sold at the farm gate to egg collectors, in the open markets to middlemen and consumers and to retail shops, hotels and supermarkets. Regular client for egg marketing in the study area were village collector/neighbors, collectors in the market and consumers as shown in Table 6. This result agrees with Desalew (2012) report in east Shewa selling eggs and chicken was practiced at local shopkeepers, village market and doorstep. The major channels through which producers/farmers sell their chicken in the markets are direct sold to consumers and/or to small retails that take the chicken to large urban centers (Kena et al., 2002). Eggs produced are sold at the farm gate to egg collectors, in the open markets to middlemen and to consumers and to retail shops, hotels and supermarkets in the towns of Dale, Wonsho and Loka Abaya weredas of southern Ethiopia (Mekonnen, 2007).

Egg transportation is difficult in the study area due to lack of standard road. Egg breakage occurs because of transportation problems. Almost 98% of farmers transport eggs by hand carrying systems using straw to reduce egg breakage. Plastic containers and *kircat* (basket) are also used to transport eggs to markets. Egg collectors and traders, often women, buy eggs from farmers and

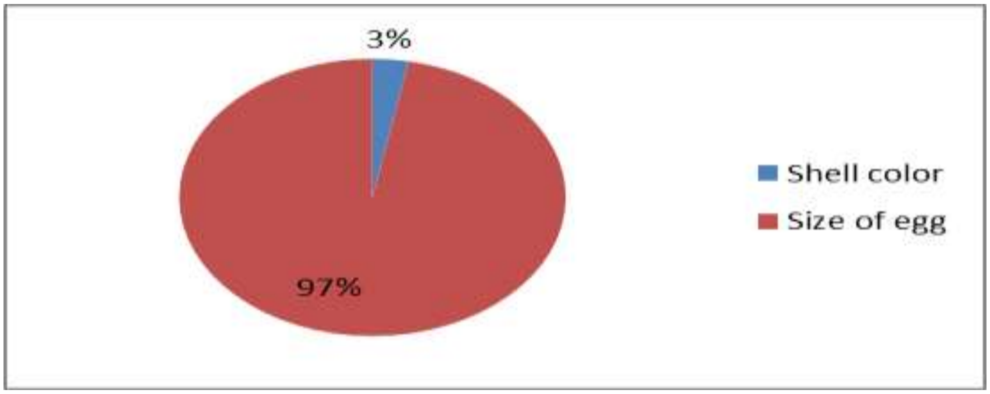

Figure 4. Determinant factors for egg marketing.

Table 7. Factors affecting egg price in Gena Bossa district.

Problems	Frequency	Percentage
Unstable egg price	61	46.2
Poor sales (demand seasonality)	18	13.6
Lack of marketing places	17	12.9
Poor infrastructure (road, market, etc.)	30	22.7
Lack of market information	6	4.5

use carton or wooden containers to transport eggs from house to market. Market price of egg in the study area was 1.78±0.03 birr. Egg market fluctuates at different time in the study district. The determinant factors for egg market were shell color and size of egg as shown in Figure 4. The average price per unit egg similar to Addis and Malede (2014) report in the average price of egg was 1.70±0.05 in north Gondar zone. There was highest number of problems which affects egg marketing in the study area as shown in Table 7. The most common problems which affects market price of eggs in the study area were unstable egg price, poor sales (demand seasonality), lack of marketing place, poor infrastructures (road and market) and lack of information as shown in Table 7. Due to lack of marketing place and access to main road in Alefa as like as live weight of chicken the price of egg was lower than Quara and Tache Armacheho districts of north Gondar zone (Addis and Malede, 2014).

CONCLUSION AND RECOMMENDATION

This study was conducted in Gena Bossa district on assessment of consumption and marketing systems of chickens and its products. This result indicates 55.1% of chickens were owned by women. Most poultry farm activities were conducted by women especially cleaning poultry house, feeding and watering. Decisions for selling, buying and providing gift were performed by both husband and wife. Farmers gave time for their chickens and 40.6% of respondents provide half a day to care chickens by feeding and watering. Chicken meat and egg consumption were connected to holiday's especially Christian festivals. Most of farmers consume chicken meat 3.64 times per year as well as they consume eggs 2.22 times per month. This shows egg and meat consumption is not common in the study even if the advantage of consuming meat and egg is higher than other foods in terms of protein contents. Marketing of poultry and its products were common in the study area. There were no formal market channels for live birds and egg marketing. Market fluctuation of live birds and eggs occur during holidays. In the study area, common problems for marketing of chickens and eggs were unstable price, demand seasonality, lack of market places, poor infrastructure and lack of market information. Depending on this result, the following recommendations are forwarded:

(i) Government, research center and health organization should give training on the importance of chicken meat and egg consumption to prevent diseases related to protein deficiency.
(ii) Government should organize production of chickens with marketing channel.
(iii) Government should minimize infrastructure related problems that affects marketing of live birds and eggs.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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Vol. 9(11), pp. 308-317, November 2018
DOI: 10.5897/IJLP2018.0458
Article Number: B02C46559009
ISSN: 2141-2448

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Aflatoxigenic fungi in Nigerian poultry feeds: Effects on broiler performance

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Received 21 February, 2018; Accepted 6 June, 2018

Aflatoxigenic fungi common to poultry feeds from Nigerian feed mills were investigated and their effects on broiler production were determined. Sixty two weeks old Abor-acre broilers were randomly divided into 5 treatment groups. Each treatment group had 3 replicates of 4 birds each. Birds in each treatment group were fed feed from one of five companies. Feed intake and body weights were determined. Blood samples were analyzed for hematological parameters. Feeds were analyzed for aflatoxin concentration using reverse phase High Performance Liquid Chromatography (HPLC). Aflatoxigenic fungi were identified by sequencing of the fungal ITS region. The major fungal contaminants identified in most of the feed samples were *Aspergillus* and *Rhizopus* species. Total aflatoxin content (AFB1+AFB2+AFG1 +AFG2) of the feeds ranged from <0.8 to 370±120 μg/kg. Feeds from three companies had aflatoxin concentrations above the European Community Regulatory Limits (ECRL, 20 μg/kg). Aflatoxin level was positively related to packed cell volume (PCV) and hemoglogin (Hb), although the relationship was not statistically significant. PCV and Hb were positively related. A negatively significant relationship was observed between the aflatoxin levels and WBC of the birds, feed intake and reduced body weight possibly because of the high aflatoxin concentrations in the feeds. The study has highlighted the effects of long storage time and poor processing of feed on intake and broiler performance.

Key words: Aflatoxin, broilers, feed, hematology, fungi.

INTRODUCTION

Contamination of food crops and feed ingredients by aflatoxigenic fungi is a common occurrence in animal feed production (Probst et al., 2010; Diedhiou et al., 2011). Cereals, concentrate, hay and other animal feeds have been reported to be substrates for the growth of fungi such as *Aspergillius* species (Scudamore and Patel, 2000; Firdous et al., 2012; Majeed et al., 2013). Aflatoxins are difuranocoumarin derivatives produced from the polyketide pathway of some strains of *Aspergillus. Aspergillus flavus* and *A. parasiticus* are the two widely known aflatoxin producing fungi, although other species such as *A. bombycis, A. ochraceoroseus*, *A. nomius* and *A. pseudotamari* have been reported to produce aflatoxin but at a relatively low level (Klich et al., 2000; Peterson et al., 2001). Within each aflatoxigenic fungal species, different strains show qualitative and quantitative differences in their aflatoxin producing abilities (Klich and Pitt, 1988). *Aspergillus flavus* contaminated groundnut meal was linked to the mysterious turkey X disease that claimed the lives of over 100,000 turkey poults near London, England (Blout, 1961). Contamination of feed crops with aflatoxin is common in the fields before harvest, where such crops are usually associated with drought stress (Diener et al., 1987). However, the most important variables that affect the contamination of such feed crops are the moisture contents of the substrate and the relative humidity of the surroundings during storage, which can promote fungal growth (Wilson and Payne, 1994).

Aflatoxin contamination has been linked to increased mortality in farm animals and thus significantly lowers the value of grains as animal feed and as export commodity (Smith and Moss, 1985). Rearing birds with aflatoxin contaminated feed can increase veterinary care costs and reduce livestock production which may cause significant economic losses to the poultry industry (Hussein and Brasel, 2001). Consumption of aflatoxin-contaminated diet by broilers has been shown to induce haematological, biochemical and liver physiological changes as well as growth depression (Che et al., 2011). In addition, haematological values of avian species are equally influenced by poultry diseases (Kokosharov and Todorova, 1989; Branton and May, 1997; Burnham et al., 2003).

Measurement of haematological parameters provides valuable information on an individual's health status. However due to lack of information, blood profile has not been widely used in avian medicine as an index to determine the health status of birds (Mushi et al., 1999). Avian blood differs in cellular composition from their mammalian counterpart (Smith et al., 2000). Some factors like physiological (Alodan and Mashaly, 1999), environmental conditions (Vecerek et al., 2002), diet contents (Odunsi et al., 1999), water and feed restriction (Galip, 1999), fasting (Lamosova et al., 2004), administration of drugs (Khan et al., 1994) and anti-aflatoxin premixes (Oguz et al., 2000) have been reported to affect the haematological parameters of birds. For example, processes such as blood-cell formation, haemoglobin synthesis, coagulation process, cellular and serum composition of blood are common haematological parameters that are easily affected by changes in the environments and physiology of broilers (Kassirskii, 2010).

Aflatoxin-contamination of poultry feeds results in increased mortality of the affected birds, decrease blood cell count, lower egg production, lower feed consumption rate, impaired resistance to infectious diseases, reduced vaccination efficiency and induced pathological damage to the liver and other organs (Kamalavenkatesh et al., 2005). Aflatoxins can act as immunosuppressive agents affecting cell-mediated and humoral immune compartments (Braz, 2005). Studies have shown that dietary aflatoxin-has both genotoxic and mutagenic effects on male Swiss albino mice (Ezekiel et al., 2011). Varying doses of aflatoxin B1 (AFB1) has been reported to affect the hematological parameters of broiler chicks resulting in depressed cellular immunity due to suppression of the phagocytic activity of macrophages and decrease in T-lymphocyte (Celik et al., 2000). Other studies showed that AFB1 concentration in the liver caused a considerable liver damage resulting in deficiency in humoral immunity (Fung and Clark, 2004). Some studies have demonstrated the use of medicinal plants and biological methods in reducing aflatoxin level in feed samples (Hassan et al., 2017a, b, c, d)

In Nigeria, commercial livestock feed companies depend solely on feed ingredients which are produced locally. Feed mill owners purchase large quantities of grains and other feed ingredients during the production seasons, and these feed stuff are used for feed production throughout the year, without any regulatory measures to control the effects of fungal growth and aflatoxin production. Furthermore, the long post-harvest periods and improper storage coupled with the tropical climate in Nigeria are known to favor fungal growth. As a result, the level of aflatoxin contamination in most livestock feeds in Nigeria may be on the increase from the delivery of grains from harvesting point, to storage for feed manufacturing and finally to poultry farms in the form of feed.

There is limited information on the growth performance and hematological parameters of Arbor-acre broilers fed aflatoxin contaminated feeds. Thus, the present study was designed to identify the major fungal agents responsible for aflatoxin production in poultry feeds in Nigeria and evaluate the level of aflatoxin contamination of poultry feeds from different feed mills. Finally, the study will investigate the effect of the aflatoxin contaminated feeds on the growth performance and

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Figure 1. The birds used in this study. The experimental birds were Abor acre broilers purchased from St Anthony's farm Akpugo and were reared in pens within the faculty of veterinary medicine animal farm, University of Nigeria, Nsukka.

Figure 2. Feed samples used in this study. (a) Feed sample with long storage time (6 months); (b) Feed sample with shorter storage time (3 months).

hematological parameters of Arbor-acre broilers in in Nigeria. The findings from this study followed guidelines for reporting in vivo experiment in animal research (Kilkenny et al., 2010).

MATERIALS AND METHODS

Broilers and feed treatments

The birds used in this experiment were purchased from St Anthony's farm Akpugo Nike in Enugu State (Figure 1). The birds were handled following the Animals Scientific Procedures Act of 1986. The 2-week old birds were acclimatized for three weeks in the Faculty of Veterinary Medicine Poultry Farm, University of Nigeria, Nsukka. During this period, the birds were given routine vaccination in addition to antibacterial and anticoccidial drugs. Poultry feeds with storage time ranging from 3 to 6 months were purchased from five commercial feed companies in Nigeria: A2, B2, C2, D2 and E2 (Figure 2). The nutrient contents of the feed samples were obtained from the information provided by the company that produced each feed. Crude protein content, fat/oil, crude fibre and metabolizable energy (ME) were recorded for each sample. The birds were randomly divided into 5 treatment groups according the feed source. Each treatment group had a total of 12 birds divided into 3 replicates of 4 birds/replicate. The birds were wing marked and birds in the same replicate were housed in pens of 1×1 m^2 size. At the 5^{th} week, the birds were given feeds from the corresponding companies. Ambient temperature, lighting, ventilation and other environmental conditions were fully met according to the requirements in the technical instructions for Arbor-

Table 1. Aflatoxin concentrations for the five feed samples analyzed in this study.

Feed samples	AFB_1(µg/kg)	AFB_2(µg/kg)	AFG_1(µg/kg)	AFG_2(µg/kg)	Aflatot
A2	<0.2 ± 0.0	<0.2 ± 0.0	<0.2 ± 0.0	<0.2 ±0.0	<0.8
B2	71.0 ± 23.0	8.3 ± 2.7	12.0 ± 3.7	1.0 ± 0.3	92 ± 30
C2	300.0 ± 94.0	41.0 ±13.0	32.0 ± 10.0	3.0 ± 1.0	370 ± 12
D2	11.0 ± 3.5	1.7 ± 0.5	1.0 ± 0.3	<0.2 ± 0.0	14 ± 4.4
E2	130.0 ± 42.0	17.0 ± 5.4	11.0 ± 3.4	0.8 ± 0.3	160 ± 51

The concentration of aflatoxin in each feed sample was expressed as means ± SD. Aflatot = Total aflatoxin.

acre broiler breeding. The birds were fed ad libitum. Feed intake was determined by subtracting the quantity of feed left after one day of serving birds in each group from the total quantity served to the birds. The average for each group was calculated and expressed as mean.

Sampling and hematological analysis

The birds were weighed at the 5th week before they were placed on the feed treatments. Blood samples were collected from the jugular veins of each bird in EDTA anticoagulant treated syringes, transferred to 2 ml Eppendorf tubes containing anticoagulants and stored for further use. Subsequent blood samples were collected from the brachial vein of the birds from each group at the 6th, 7th and 8th week (Bermudez and Stewart-Brown 2003). Hematological analysis included counts of red blood cell (RBC), white blood cells (WBC), packed cell volume (PCV) and hemoglogin (Hb). In addition, the absolute counts of heterophils, lymphocytes, monocytes, eosinophils and basophils were determined following routine procedures. For the PCV and RBC counts, microheamatocrit method was used (Cole, 1986). Total Hb was determined using cyanmethemoglobin method (Brown, 1984). Total WBC count was determined as described previously by Schlam et al. (1975). Other hematological parameters were determined using routine methods (Campbell, 1988). Body weight measurements and feed intakes were also determined on individual bird at weekly intervals from the 6th to 9th week during the course of the treatments.

Fungal isolation and identification by PCR amplification of the ITS region

About 2 g of the feed samples fed to the birds in each group was ground to a fine powder using a mortar and pestle. The ground feed samples were transferred to labeled test tubes and 8 mL of sterile distilled water was added to each tube. The mixture was homogenized with a vortexing machine. Aliquots of 0.2 mL were collected from each tube and spread on freshly prepared SDA and PDA media (Oxoid, Cambridge, UK) and incubated for 5 days at 25°C. To produce a pure culture of each fungus, fungal colonies with homogenous morphology were picked from each plate and transferred to new PDA plates and incubated for another 5 days at 25°C. Genomic DNA was extracted from the pure cultures (Oxoid, Cambridge, UK) using a hexadecyltrimethylammonium bromide (CTAB-based method; Nygren et al., 2008). DNA concentrations were determined spectrophotometrically using NanoDrop (Thermo Scientific, Wilmington, DE). Dream Taq DNA polymerase (Thermo Scientific, Wilmington, DE) was used for PCR amplification of the highly conserved fungal internal transcribed spacer (ITS) region using primer pairs ITS1F and ITS4 as previously described by White et al. (1990). Amplified PCR products were purified using ethanol-sodium acetate precipitation protocol and sequencing was performed by Macrogen Europe (Amsterdam, The Netherland). Sequence data were used for BLAST searches in GenBank at the National Center for Biotechnology Information (NCBI-www.ncbi.gov).

Aflatoxin analysis by reverse phase HPLC

Aflatoxins in the feed samples were analyzed following the procedure described by Barmark and Larsson (1994). Briefly, 10 g of the feed samples from each treatment group was weighed and ground to a fine powder using a mortar and pestle. The ground feed samples were transferred quantitatively to extraction tubes containing 80% (v/v) aqueous acetonitrile. The tubes were placed on a rotary shaker for 45 min for extraction. The extract was filtered through folded filter paper (Schleicher and Shuell 597½); a 1 mL aliquot was diluted with 40 mL de-ionized water and mixed thoroughly. The diluted extract was purified on immuno affinity columns (Vicam AflaTest, Waters Corp.). The purified extract was analyzed by reversed phase HPLC (Shimadzu Corp.) with isocratic elution and fluorescence detection after post column derivatization with bromine by the KOBRA CELL® (Rhone Diagnostics, Glasgow UK). Each feed sample was analyzed for the four known aflatoxins-aflatoxin B_1 (AFB_1), aflatoxin B_2 (AFB_2), aflatoxin G_1 (AFG_1) and aflatoxin G_1 (AFG_2).

Statistical analysis

'R' statistical package was used for data analysis. A generalized linear model (glm) with Gaussian error structure was used, with the significance level set at P<0.05 (Mathsoft, 1999). The effect of aflatoxin was treated as a dependent variable while weight gain, feed intake, RBC, PCV, WBC and Hb were independent variables. Furthermore, the analyses included the interactions of Hb with WBC and Hb with PCV. Model selection was carried out using step-wise backward single term deletion of non-significant variables, starting with the interactions.

RESULTS

Aflatoxin analysis

The four aflatoxins were detected in the feed samples but at varying concentrations (Table 1). Feed samples B2, C2 and E2 had high concentrations of AFB_1 higher than the recommended limits in livestock feeds. The same trend was maintained for these feed samples for AFB_2 and AFG_1 but at relatively lower levels. Feed samples A2

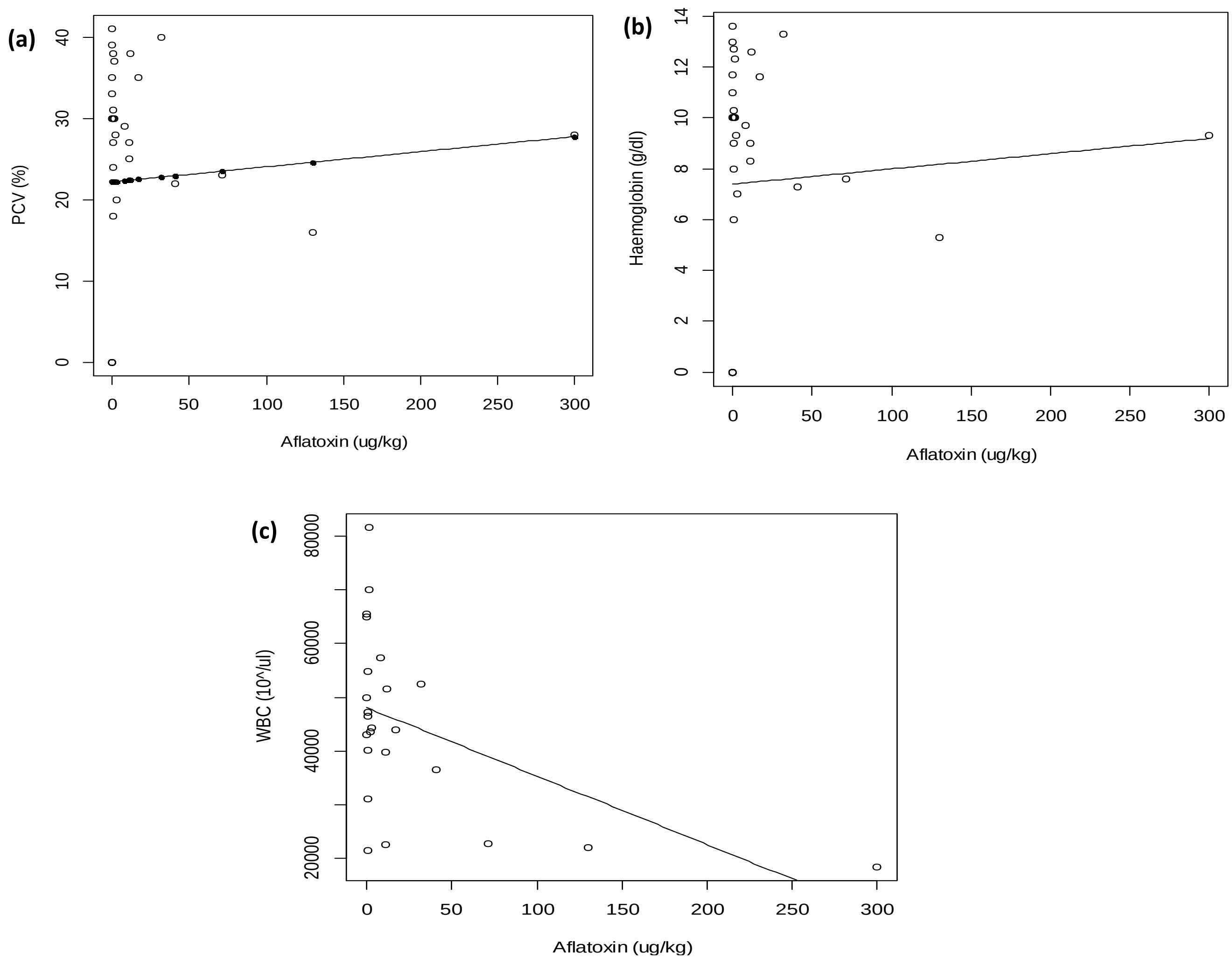

Figure 3. Relationships between aflatoxin concentration of the feeds and some tested blood parameters; (a) Relationship between aflatoxin and PCV (P=0.45, B=3.85); (b) Relationship between aflatoxin and Hb (P= 0.54, B= 0.92); and (c) Relationship between aflatoxin and WBC (P=0.03, B=-0.01).

Table 2. Summary table for relationship between aflatoxin and body condition of the experimental birds.

Parameter	Estimate	Std. error	t value	Pr(>|t|)
Intercept	8.10	1.82	0.05	0.96
Hb	9.20	1.50	0.62	0.54
PCV	3.85	5.00	0.77	0.45
WBC	-0.01	0.01	-2.27	**0.03**
Hb:PCV	0.41	0.18	2.24	**0.03**

Significant values are in bold. Although Hb and PCV are not significant, they are however left in the model because the interaction between them is significant.

and D2 were the only samples that had aflatoxins below the recommended level. There was no statistically significant relationship between the aflatoxin level in the feed and weight gain; aflatoxin level and feed intake and aflatoxin level and RBC of the birds. Aflatoxin level was positively related to PCV but the relationship was not statistically significant (Figure 3a and Table 2; P = 0.54, B = 0.92). Furthermore, the aflatoxin level was positively related to Hb but also was not statistically significant (Figure 3b and Table 2; P= 0.45, B=3.85). A negative

Table 3. Nutrient composition of the feeds utilized in this study.

Nutrient	Feed A2	Feed B2	Feed C2	Feed D2	Feed E2
Crude protein (%)	18.0	17.0	23.0	18.0	19.0
Fat/oil (%)	6.0	10.0	10.0	6.0	2.9
Crude fibre (%)	5.0	15.0	10.0	5.0	6.0
M.E (kcal/kg)	2900	3000	2830	3000	2875

The nutrient composition of each feed was obtained from the information provided by the companies sampled in this study.

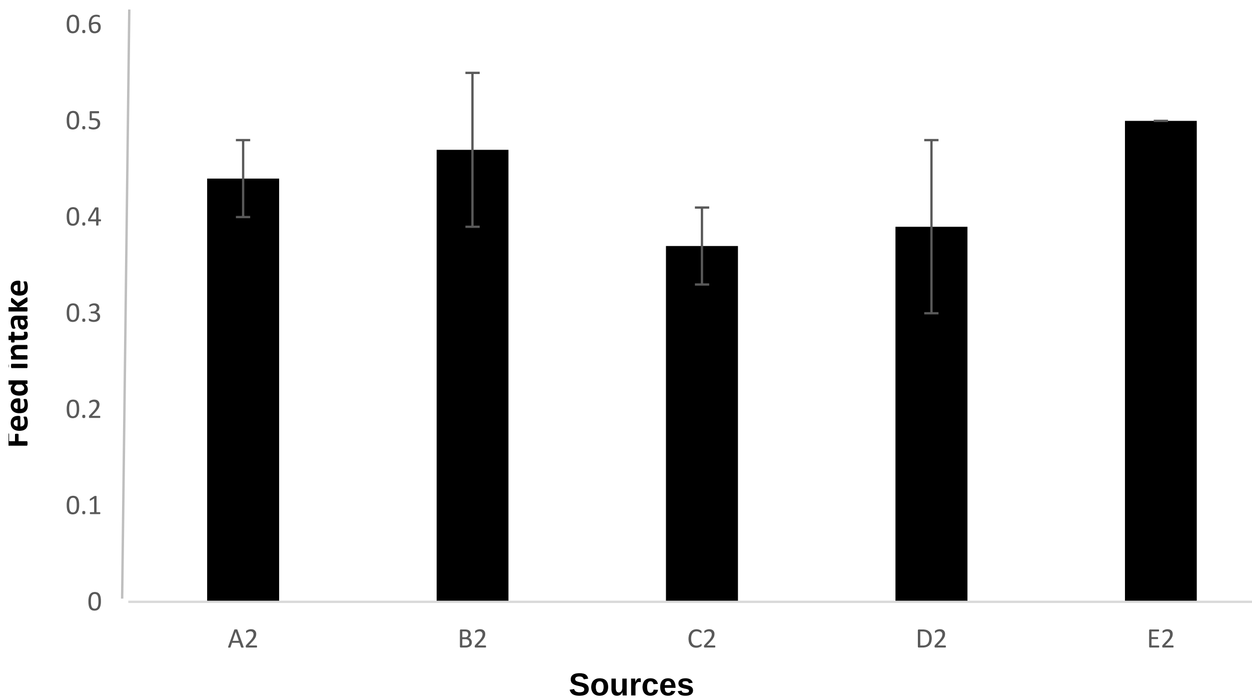

Figure 4. Feed intakes of the Abor-acre broiler birds given feeds from five different sources. The birds were fed ad libitum. Feed intake was determined by subtracting the quantity of feed left after one day of serving birds in each group from the total quantity served to the birds. The average for each group was calculated and expressed as means. The bars are averages of 4 different measurements taken at different time intervals.

statistically significant relationship was observed between the aflatoxin level in the feeds and the WBC of the birds (Figure 3c; $P = 0.03$, B = -0.01).

Nutrient composition of the feeds, intake and broiler performance

The nutrient composition of the 5 feed samples is presented in Table 3. The fat/oil content and crude fibre content were highly variable between the feed samples. The feed samples had different levels of mould contamination (Figure 2) and this negatively affected the feed intake. Birds in groups C2, D2 and E2 had relatively reduced feed intakes whereas birds in groups A2 and B2 had better feed consumption rates (Figure 4). A similar trend was observed in the body weights of the broilers in each group. The broilers in groups C2, E2, B2 and D2 had reduced weight gain (Figure 5); whereas, the birds in Group A2 had relatively higher weight gain.

Haematological analysis

The haematological parameters are presented in Table 4. Birds in each group showed increased WBC counts, PCV values and hemoglobin values. Although the lymphocyte counts were relatively high; they varied among the groups. The average total RBC count in all the groups were low while the mixed blood populations, heterophils, monocytes, eosinophils and basophils were scantly represented in some of the groups. However, a

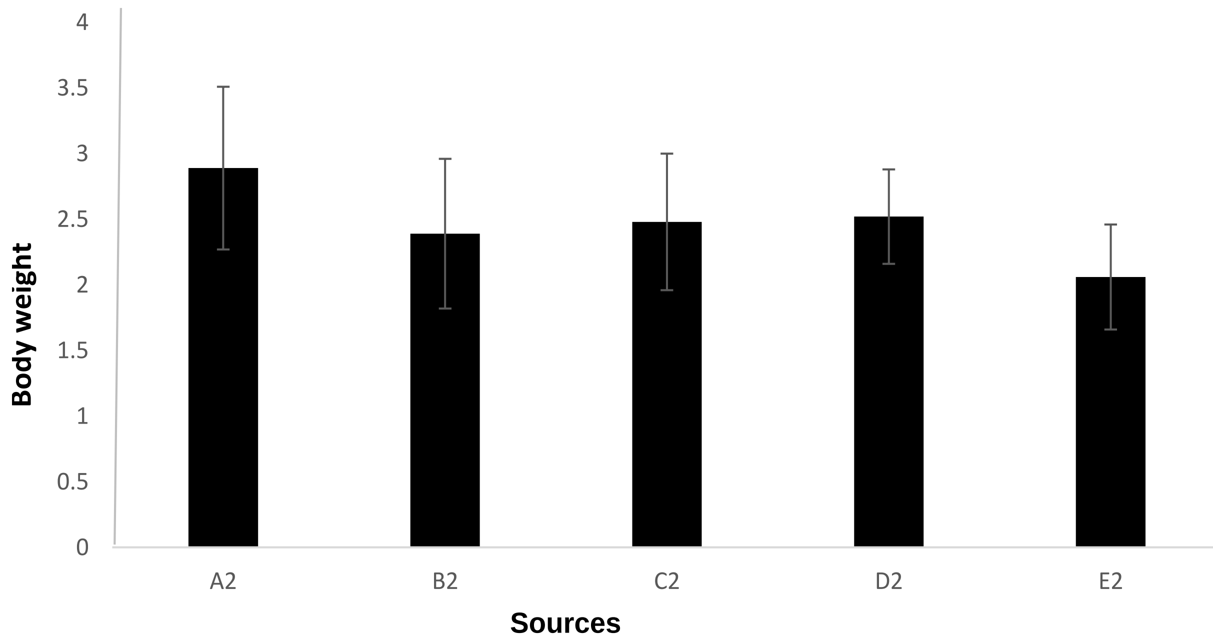

Figure 5. Body weights of Abor-acre broilers fed feed from five different sources. Body weight of individual bird in each group was measured at different time intervals and the average for each group was determined and expressed as means. The bars are averages from 4 different measurements taken at different time intervals.

Table 4. Heamatological parameters of Abor-acre broilers fed feeds with different aflatoxin concentrations.

Feed sample[a]	RBC count (10^6/µl)	WBC count (10^6/µl)	PCV (values %)	Haemoglobin (g/dl)	Lymphocytes	Mixed
A2	7.1 ± 6.6	47.8 ± 9.4	37.6 ±5.2	12.5 ± 1.7	nm	nd
B2	7.2 ± 4.6	47.7 ± 3.4	33.8 ± 7.5	11.3 ± 2.4	28.8 ±5.5	nd
C2	3.4 ± 0.7	49.9 ± 7.8	34.0 ± 5.5	11.2 ± 1.8	20.0 ±4.4	nd
D2	2.9 ± 1.2	56.0 ± 14.4	33.0 ± 4.7	10.0 ± 1.5	16.8 ±9.0	nd
E2	2.6 ± 0.7	43.1 ± 7.8	32.5 ± 5.3	10.8 ± 1.8	8.5 ±1.9	nd

The hematological values of individual bird in each group were determined and expressed as means ± SD; [a] = Feed samples fed to birds in different group. nd = not detected; nm = not measured.

statistically significant relationship between PCV and Hb was observed (P = 0.03, B = 0.41).

Identification of aflatoxigenic fungi by ITS sequencing

Heterogeneous growth of fungi with mixed morphological appearance was observed. However, after sub culturing, 2 pure cultures were obtained from the feed samples in each group. *Aspergillus* species were common in the feed samples fed to birds in Groups B2 and E2. *Rhizopus oryzae* was isolated from feed samples A2, E2 and C2. Other fungal species identified in this study include *Trichosporon asahii* from feed sample D2. All the identified fungal species had between 99 and 100% sequence identities with existing sequences in the Genbank. However, some of the samples were contaminated during the PCR reaction and could not proceed to the sequencing and identification stage.

DISCUSSION

Feed contamination by aflatoxins is a major problem in the tropics and the major fungal organisms implicated in this problem are the *Aspergillus species,* especially *A. flavus* and *A. parasiticus* (Donner et al., 2009; Diedhiou et al., 2011). Among the isolated fungal species, *Aspergillus* species (*A. flavus* and *A. oryzae*) and *Rhizopus species (R. oryzea*) were the most common contaminants found in the feeds in the present study.

From our analysis, the four known aflatoxins (AFB_1, AFB_2, AFG_1 and AFG_2) were present in the feeds at varying concentrations. Feeds C2 and E2 had the highest aflatoxin contents; 58.1 and 25.1%, respectively. The high concentration of aflatoxin in these feed samples could be as a result of long storage time or poor processing methods in the source companies. It is also possible that the concentration of aflatoxins in these feed samples could be as a result of problems with the feed ingredients. Other studies have reported heavy contamination of feed ingredients used in poultry feed production with *Mucor* and *Rhyzopus* species due to the high carbohydrate content of the ingredients (Infeanyi et al., 2007; Ariyo et al., 2013). Studies have also reported high contamination of common feed ingredients such as maize, rice, peanut meals and barley used in livestock feed production (Firdous et al., 2012; Sherazi et al., 2014). These feed crops mature in the seasons characterized by hot temperatures and high humidity, as a result, the chances of contamination with fungal infections are quite high (Ratnavathi et al., 2012). Furthermore, *A. flavus* can infect maize crops prior to harvest and remain viable during storage (D'Mello, 2000).

In this study, AFB_1 was found in concentrations far beyond the recommended limits in most of the feed samples analyzed. For example, feed samples B2, C2 and E2 had 71.0, 300.0 and 130.0 µg/kg average concentrations of AFB_1 respectively which are doses far much higher than the recommended limits of 100 ppm in poultry feeds by the United States (FDA, 2003). The European community recommended a maximum AFB_1 content level of 20 and 10 ug/kg for whole feed in poultry and chicks, respectively (Jewers, 1987). AFB_1 is a toxic aflatoxin that induces hepatic cell necrosis, haemorrhage and hepatocellular carcinomas in animals (Khan et al., 2010). At levels of even less than one part per million (ppm), AFB_1 is capable of damaging cells within an organism (Van Kessel and Hiang-Chek, 2004). The acute toxicity of AFB_1 in poultry varies from species to species. For ducklings and chickens, the LD_{50} single dose (mg/kg body weight) is 0.3 and 6.0 to 16.0, respectively. Poultry diets containing 250 to 500 ug/kg of aflatoxins have been shown to predispose birds to attacks by bacteria and viruses (Edds et al., 1973).

Feed intake and body weight differed among the different groups of birds. For example, birds in groups C2, D2 and E2 had reduced feed intake and consequently reduced body weight possibly because of the high aflatoxin concentrations in the feeds, although this could not be statistically proven in the study's analysis. The differences in feed intake and body weight could also be explained by the nutrient contents of the feeds. Although, the variation in the nutrient contents of the feeds was not high; feeds from companies C2, D2 and E2 had relatively high protein contents. Feed intake was relatively higher for the birds in group B2 and the corresponding body weight of the birds in this group was also high. It could be that the feed given to this group of birds was more palatable possibly because of its high crude fibre content. Although the study's analysis in this study was limited to aflatoxin; it is possible that other mycotoxins in the feed may have partly contributed to some of the observed conditions in the birds. In a different study, deoxynivalenol was reported to have reduced feed intake and weight gain in birds by 26%; the same study also demonstrated a 16% reduction of feed intake in response to aflatoxin B1 (AFB1) (Andretta et al., 2012).

Hematological values of avian species are used as performance index in determining the health condition of birds (Vecerek et al., 2002). Hematological values are influenced by poultry diseases and other health related conditions (Kokosharov and Todorova, 1987). There were positive relationships between the aflatoxin level in the feeds and the following hematological parameters, PCV and Hb, but the relationships were not statistically significant. The lack of statistically significant relationship between the aflatoxin level and Hb and aflatoxin level and PCV, does not reduce the physiological or clinical values of the result. However, the interaction between PCV and Hb in the birds fed aflatoxin contaminated feed was statistically significant. Furthermore, the aflatoxin contaminated feed decreased the WBC level of the birds and this was statistically significant. These results indicate alteration in haemostasis and blood system damage possibly induced by the aflatoxin. In contrast Che et al. (2011) reported increased WBC level induced by mold contaminated feed**.** Also, Abbès et al. (2006) reported a significant increase in WBC after some mice were treated with 500 mg/kg ZEN. The differences in results from the three independent studies could possibly be explained by the storage period of the feeds, level of contamination by other mycotoxins and perhaps by the level of consumption of the contaminated feeds. From the study, it could be concluded that poultry feeds stored for a long time can negatively affect the general performance of Abor-acre broilers and this could have negative economic impact on the farmer. Also the study showed variations in feed processing methods, this calls for a more standardized approach that will ensure the production of quality feeds that can withstand the deteriorative effects of environmental agents during storage.

Compliance with ethical standards in experiments involving the use of animals

The authors declare that during the course of this experiment, no animal was treated in an inhumane manner. Animal management and facilities were in accordance with the ethical standards involving the use of animals for *vivo* experiment. All authors who participated in this experiment read the manuscript and gave their consents for submission.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Vol. 9(11), pp. 318-325, November 2018
DOI: 10.5897/IJLP2018.0499
Article Number: 623B45259011
ISSN: 2141-2448

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Beef edible red offal condemnations in Kgatleng Slaughter Facilities, South eastern Botswana in a wet and dry season period

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Received 14 June, 2018; Accepted 7 August, 2018

The study aimed to determine pathological conditions across two seasons, leading to condemnations of beef edible red offals in Kgatleng District, Botswana. Offals are valued in communities of Botswana. Data from slaughter facilities was evaluated for dry/winter and wet/summer seasons. Financial losses were also determined. 7405 cattle were processed in the two seasons, with 4005 cattle slaughtered in the dry season and 3400 in the wet season. Of the slaughtered cattle, 55.2% (2209) of the dry season and 45% (1531) of the wet seasonhad some forms of pathological conditions that led to condemnations of the offals. Lungs were highly condemned at 26.2% in the wet season and 32.7% during the dry season, followed by livers at 16.2 and 18.4% in the wet and dry seasons, respectively. Emphysema led to a condemnation rate of lungs at 20% and 17% for the dry and wet seasons, respectively. The least condemned offals were the spleen at 2.3% (wet season) and 2.1% (dry season), followed by the kidneys at 0.3% (wet season) and 2% (dry season). Financially, the dry season losses were relatively higher at BWP62 950.55 compared to the wet season at BWP43 863.95. Management strategies should be put in place to avail offals to consumers.

Key words: Beef, edible red offals, pathological conditions, wet and dry seasons.

INTRODUCTION

Botswana depends greatly on cattle for meat and milk consumption, and to generate income from meat and its associated byproducts such as edible organs/offal. Beef cattle farming in Botswana is an important socio-economic and cultural function in the lives of rural communities (Sharma, 2014; BIDPA, 2006). In Botswana, livestock offal's are highly valued across different communities, where they are consumed as a cheaper alternative to meat, which is relatively more expensive and unaffordable to the rural poor. Different communities and or tribes use livestock offals, that can either be edible or inedible. Amongst edible offals are livers, hearts, tongues, tails, kidneys, brains, sweetbreads (the thymus and/or pancreas gland, depending on an animal's age), tripe (stomach), melt (spleen), chitterlings and natural casings (intestines), fries (testicles), rinds, head meat, lips, fats

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and other trimmings, blood, and certain bones (Bowater and Crustafson, 1988; Devatkal et al., 2004; Marti et al., 2011). Edible beef offals can be grouped into red, amongst them liver, kidneys, spleen, heart and lungs or green offal which include rumen, intestines and omasum. Red offals are not in contact with the contents of the digestive tract as compared to green (grass) offals (Bowater and Crustafson, 1988). These organs are mostly and readily available locally, in slaughter facilities and some retail stores. They tend to be relatively cheaper and affordable compared to standard meat cuts. Offals just like standard meat portions contain essential nutrients and minerals (Gracey et al., 1999; Warriss, 2000). Locally, beef edible offals just like carcasses, are usually inspected by veterinary personnel of the Ministry of Agriculture and Food Security at post-mortem in slaughter facilities, and at times condemned due to diseased conditions and or abnormalities. These condemnations lead to great economic losses to both the farmer and the meat processing industries.

Parasitic diseases are responsible for most condemnation of offal in slaughter facilities and therefore the main cause of related economic losses (Addis, 2017). Parasitic diseases also contribute to limiting factors for the full development of livestock export trade hence resulting in great financial losses to exporters (Mohamed et al., 2012). In addition to diseases, lack of appropriate slaughtering facilities and inappropriate slaughtering techniques cause unnecessary losses of meat as well as invaluable by-product from animal carcass, which may include offal. Cattle are affected by a variety of internal parasites, and among these are roundworms (nematodes), which are primarily parasites of the gastrointestinal tract with lung included and the liver fluke (trematodes) (Williams and Barker, 2001; Yimam, 2003). Periods of great infection risk occur from late winter through spring, and considerable infection may also occur during milder winters and during summers that are very wet and not overly hot (Williams and Barker, 2001). Under pasture conditions, it is common to encounter mixed infections with several types of roundworms as well as with other parasites as reported by Williams and Barker (2001). Additionally, animals grazing in swamps, marshy or flooded regions or close to water places are exposed to high risk of becoming infected with the tropical liver and also to an array of other parasites (Mesele et al., 2012). Previous studies have indicated a higher loss resulting from condemnations of edible organs and carcasses due to parasitic causes leading to offal condemnations (Negategize et al., 1993; Jembere, 2002; Aseffa 2005; Jibat, 2006). Parasitism is one of the major bottlenecks to livestock development in the tropics (Kassai 1999; Hansen and Perry, 1994; Keyyu et al., 2003; Max et al., 2006), Parasites often leads to abnormal conditions such as fascioliasis, peritonitis, hydatidosis and emphysema in livetsock. Fascioliasis has been found to lead to direct and indirect economic impacts on livestock production in sheep and cattle resulting into death, loss of carcass weight, reduction in milk yield, condemnation of affected livers, and decline in production (reproductive production) performance, predisposition of other diseases and cost of treatment among others (Kassuku et al., 1986; Hammond and Sewell 1990; Wamae and Ihiga 1991; Menkir et al., 2007; Mungube et al., 2006). It is necessary to have clear information on major causes of organ/offal and carcass condemnations at slaughter facilities. This is important in providing information on where and how to reduce the product and financial losses, caused by the various abnormalities and or diseases in the livestock and meat industry (Jembere, 2002; Yimam, 2003; Aseffa, 2005; Getachew, 2008; Regessa et al., 2013). The main objective of this study was to evaluate condemnations records of beef edible red offals due to major pathological conditions in the Kgatleng Veterinary district, South Eastern Botswana. The study also aimed to investigate the influence of seasonality on the condemnations and financial losses relating to condemnation of red beef offals in the slaughter facilities.

MATERIALS AND METHODS

Study area

Kgatleng Veterinary area falls within the Kgatleng district, south Eastern Botswana. The area is 1014 m above sea level, and located between 24° South and 26° East latitude and longitude, respectively. The District has six slaughter facilities, namely; Mapole, Monakgomo, Mmadipinose, Lorato, Wataola and Kamo. Cattle slaughtered at these slaughter facilities are sourced from different extension areas within the district with various crush facilities used for their collection. Farmers are mainly of resource poor type, on communal grazing lands with relatively poor herd health management.

Study design

The study reviewed veterinary post-mortem slaughter records from the six slaughter facilities in the area. Major pathological conditions leading to red edible offals were identified as data entries over a total of eight months. The data was segregated into two seasons (four months each), being dry (winter; May to August 2015) and wet (summer; December, 2015 to March, 2016). Cattle slaughtered in these facilities are inspected by Government Meat Inspectors, following the standardized veterinary guidelines for ante-mortem and post-mortem inspection as per the Meat Industries Act (Botswana Government Printers, 2011), and such data is stored and available at District Veterinary Offices, Mochudi Veterinary Office in this case.

Data collection and analysis

Data collected was cleaned and verified. It was thereafter processed into spreadsheets and analysed using percentages to determine condemnation rates of the offals. Data evaluated was on beef edible red offals, being the lungs, livers, spleen and kidneys. Pathological conditions were identified that led to condemnations of each offal, and an estimate price per kg was used to calculate

Table 1. Wet season versus Dry season overall condemnations per offal (%).

Organ	Wet season	Dry season
Lungs	26.2	32.7
Livers	16.2	18.4
Spleen	2.3	2.1
Kidney	0.3	2
Total carcasses affected	1531	2209
Percentages	45	55.2

NB: Total cattle slaughtered for wet season (n = 3400) and dry season (n= 4005).

losses, using averaged prices in a major retail shop selling the same offals. Over the two seasons, a total of 7405 cattle were slaughtered across the six slaughter facilities. The number consisted of 4005 cattle slaughtered during the dry (winter) season and 3400 slaughtered during the wet (summer) season.

RESULTS AND DISCUSSION

Post-mortem data obtained from the Kgatelng Veterinary Office at Mochudi showed that a total of 7405 cattle were processed in the district's slaughter facilities in the two periods reviewed (May 2015 to March 2016). During the dry season, a total of 4005 were slaughtered, with a total of 3400 cattle slaughtered during the wet season. Of the slaughtered cattle, 55.2% (2209) in the dry season and 45% (1531) in the wet season suffered major pathological conditions that led to condemnations of the edible red offals extracted from them (Table 1). Ideally, as meat is the main source of protein to humans, it should be clean and free from diseases of particular importance to public health such as tuberculosis, hydadosis, fascioliasis among others (Williams, 2001). Meat inspection, in the Kgatleng slaughter facilities comprises of ante mortem and post mortem examination, to remove gross abnormalities from meat and its products, prevention of distribution of contaminated meat that could result to disease risk in man and animals and assisting in detecting and eradication of certain diseases of livestock (Van, 1993; Herenda et al., 1994; Teka, 1997; Gracey et al., 1999). The existence of conditions leading to offal condemnations in the Kgatleng slaughter facilities indicates poor herd health by farmers. Farmers in the district are mainly subsistent and on communal areas. In such areas livestock mix across herds in grazing areas and are usually overstocked, making them prone to parasitism and poor health. To control these conditions and improve livestock production efficiencies, farmers should put in place management strategies that control gastrointestinal tract nematodes, and lung worm with a planned and systematic effort to simultaneously control liver fluke and ectoparasites, such as flies, lice and grubs. This further depends on prevalence in a given geographical area. However, good control of all parasites along with good overall herd health is the best guarantee of increased productivity (Williams, 2001). The current study shows that beef edible red offals in Botswana, just like in other countries like Egypt, Ethiopia and Tanzania, go to waste in the slaughter facilities (Mellau et al., 2010; Ahmed et al., 2013; Mesfin et al., 2015). This situation leads to a threat to food security and financial losses in the country. Further, conditions leading to these condemnations pose a health hazard to meat consumers, farmers and the general public (Table 1).

Lungs

Lungs were highly condemned in both seasons due to conditions emphysema, hemorrhages and hydatidosis (Table 2). The emphysema condition led to a higher condemnation rate in this offal class at 20.6% and 17% for the dry and wet seasons, respectively. The hemorrhage condition contribution was comparable between the seasons at about 4% across the two seasons. Hydatidosis led to an 8.7 and 4.8% lungs condemnation in the dry and wet season, respectively. The emphysema condition that led to higher condemnation rates of lungs is an abnormal permanent enlargement of air spaces distal to the terminal bronchiole and destruction of alveolar septal walls without apparent fibrosis as was earlier explained by Mesfin et al. (2015) and Opara (2005). Mesfin et al. (2015) found hydatidosis condition as a major contributor to condemnation of lungs in the Dessie Municipal abattoir in North east of Ethiopia in a dry season period. This condition's contribution was much lower at 8.7% compared to the current study at 20.6% during the dry season and 17% during the winter season. It should be noted though that, the dry season period in Ethiopia is November - April compared to May – August in Botswana. Similar results on high lung condemnations due to the Emphysema condition during post-mortem were found by Mellau et al. (2010), who reported a 13.1% contribution rate at Arusha Abattoir in Tanzania.

In Ismailia, Egypt, Ahmed et al. (2013) reported higher lungs condemnation rate of up to 44.6% of all condemned organs. This report showed a high condemnation rate of lungs compared to the Kgatleng District data of south

Table 2. Edible red offal's condemnations due to major pathological conditions at Kgatleng slaughter slabs during the dry season (May 2015 to August 2015, Total carcasses affected n = 2209) and wet season (December 2015 to March 2016, Total carcasses affected n = 1531).

Red Offal	Condition	Dry Season		Wet Season	
		Offals affected	(%)	Offals affected	(%)
Lungs	Emphysema	824	20.6	578	17
	Hemorrhages	135	3.4	150	4.4
	Hydatidosis	347	8.7	162	4.8
Liver	Peritonitis	294	7.7	215	6.3
	Abscess	236	5.9	178	5.2
	Stelecia hepatica	209	5.2	159	4.8
Spleen	Peritonitis	63	1.6	62	1.8
	Muttilation	9	0.2	8	0.2
	Congestion	12	0.3	9	0.3
Kidney	Infarcts	15	0.4	1	0.02
	Congenital cyst	25	0.6	2	0.1
	Anemia	12	0.3	0	-
	Hydronephrosis	28	0.7	7	0.2

NB: Total cattle slaughtered for the dry season, n = 4005 and total cattle slaughtered for the wet season, n = 3400.

eastern Botswana. High Egyptian condemnation rate may be linked to the dry, windy and sandy ecosystem compared to that of Botswana. Exposure of animals to stress factors like dust, overcrowding and exhaustion from long treks in search of pasture and water during the dry season may also contribute to respiratory conditions (Kusiluka and Kambarage, 1996). Because of their anatomical and histological characteristics, lungs are perhaps the most exposed to physical, chemical and biological injuries. This is supported by the findings of this study which revealed higher levels of condemnations at 32% and 26.2% in the dry and wet seasons, respectively. Under poor herd health, livestock is also predisposed to parasitism, mainly endoparasites due to deficiencies during the dry period. It is during the dry season that livestock tend to nibble on foreign material due to deficiency cravings, risking infestation. Ruminants particularly cattle, have well developed interlobular septa and lack of collateral ventilation, making them more susceptible to interstitial emphysema (Mellau et al., 2010). Pulmonary emphysema is also caused by obstruction of airflow or by extensive gasping respiration during the slaughter process (FAO, 1994). More conditions leading to lung condemnations are reported by Ahmednur et al. (2015) for Dire Dawa Municipal Abattoir, Eastern Ethiopia. Lung condemnations of hemorrhage, emphysema, hydatid cyst, pneumonia and abscessation at 59, 17, 13, 6 and 5%, respectively were found.

Livers

Livers were second in condemnation rate due to conditions peritonitis, abscesses and stelecia hepatica in the Kgatleng District slaughter facilities. All the three conditions recorded as having led to liver condemnations in the district were comparable, and lower than 10% across the two seasons. The peritonitis condition led to a condemnation rate of 7.7% during the dry (winter) season and 6.3% in the wet season (Table 2). Bovine liver is one of the largest visceral organs in the animal body, which performs numerous functions and a very rich source of vitamins and minerals (Ibironke and Fasina, 2010). This offal is much sought by consumers and food traders both locally, and in other countries like Nigeria due to its palatability and ease of consumption (Ibironke and Fasina, 2010). However, it is one of the most commonly condemned visceral organs during routine meat inspection (Ibironke and Fasina, 2010). Compared to the current study, Ethiopian studies showed higher condemnations rates for livers. Abunna et al. (2013) reported total condemnation rate of up to 39.7% out of 953 slaughtered in Southern Ethiopia from gross abnormalities. The authors noticed that livers were the most condemned organ in the Dire Dawa municipal abattoir in the period of five months from November 2014 to March 2015, a dry season in Ethiopia. In the current study, liver condemnations were much lower in a similar season, at 18.4%. The main difference between the dry seasons of Botswana and Ethiopia is that, for Botswana, the season is both dry and cold (winter), whereas in Ethiopia the season is relatively warm. The warm weather during this period in Ethiopia may be conducive to disease causing organisms that lead to abnormalities in livers. Still in Ethiopia, Ahmednur et al. (2015) reported a high percentage of liver condemnation at 73.8% out of a total 17.3% of examined organs post-mortem. Mesfin et al. (2015) also reported high rate of 40.5% in the same region of north eastern Ethiopia for the dry season. Another study by Bogale et al. (2012) reported higher condemnation rates for the liver in northwestern part of Ethiopia, at 34.3% for the dry season, compared to the current study in Botswana. The temperature difference of the dry season in Botswana and Ethiopia, may be having an effect on the vulnerability of organisms leading to liver abnormalities, thus bringing these differences in condemnation rates in the two countries.

Stelecia hepatica condemnation contribution for both seasons in this study is comparable to 8.6% reported by Mellau et al. (2010) at an abattoir at Dodoma, Tanzania. A much higher condemnation rate due to Stelecia Hepatica at 30%, was reported by Kamwela et al. (2013) still in Tanzania, at an abattoir in Kigoma. Studies conducted in Ethiopia have also reported higher contributions to liver condemnations by Stelecia hepatica (Mohammed et al., 2012). This shows that Stelecia hepatica is a large burden in cattle in other African countries compared to Kgatleng District in Botswana. Although Stelecia hepatica rarely causes mortalities in cattle, its effects result in reduced production and condemnation of livers during meat inspection in abattoirs (Abunna et al., 2013, Addis, 2017). Such livers are usually declared unfit for human consumption and disposed off, leading to abattoir losses financially and a loss to human nutrition of a cheaper protein source. Abunna et al. (2013) in Wolaita Soddo Municipality Abattoir, Southern Ethiopia reported that the liver is the most often condemned organ. Conditions leading to liver condemnations mostly encountered in abattoirs during post-mortem inspection are macroscopic lesions, due to parasitic infections, resulting in fasciolosis, hydatid cyst, abscess, lesions, calcification and cirrhosis (Abunna et al., 2013). These conditions were observed even in the current study, contributing to liver condemnations. Of the condemned livers in Gondar abattoir at Northwest Ethiopia November 2011 to April 2012 reported by Bogale et al. (2012), fasciolosis was responsible for 48.5%, hydatidosis for 17.9% and cirrhosis for 15.4%. These conditions indicates poor herd health in Botswana just like in Ethiopia. In communal systems of Botswana, deworming strategies are very minimal if not none existent. Fasciolosis is caused by by *Fasciola hepatica*, a trematode (fluke) parasite that infests humans and many species of animals (Mesfin et al., 2015, Addis, 2017).

Spleen

This red offal had a low condemnation rate compared to lungs and the liver, and this was due to conditions peritonitis, congestion and mutilation.

The peritonitis condition had a relatively higher contribution to condemnations of this offal class, at around 2% for both seasons. Other conditions led to condemnation rates lower than 1% (Table 2). This offal class tended to have an overall low condemnation rate, even in the study by Tembo and Nonga (2015) in Dodoma, Tanzania where a condemnation rate lower than 1% was reported for both dry/winter and wet/ summer. Further, the study reported a much higher rate due to peritonitis condition at 23.3%. Compared to Botswana which has cold and warm seasons, Tanzania is always much warmer, which might explain the reported high condemnation rate in Dodoma abattoir. High temperature and moist ecosystems are ideal for microbial proliferation, leading to diseased organs of livestock.

Kidneys

Kidneys just like the spleen had a low condemnation rate in the Kgatleng Veterinary district during the two seasons. Conditions recorded for this offal class condemnations were infarcts, congenital cysts, anaemia and hydronephrosis (Table 2). These conditions led to condemnation rates lower than 1% across the two seasons. Ahmednur et al. (2015) in Ethiopia, reported that out of the 6442 cattle which were slaughtered at Dire Dawa municipal abattoir in a period of five months, from November 2014 to March 2015 which is a dry season too, condemnation rate was at 1.3% for kidneys. The results were comparable with those of the current study. Abunna et al. (2013) and Mesfin et al. (2015) in Ethiopia, reported liver condemnation rates of 3.2%) and 5.1%, at Wolaita Soddo and Dessie municipal abattoirs, respectively. These figures are relatively higher compared to those obtained by the study. The differences may be accounted to the different temperatures during the dry season between Botswana and Ethiopia. Botswana's dry season is much cold, whereas the Ethiopian dry season is much warmer.

In the current study, congenital cysts and hydronephrosis tended to contribute more to kidney condemnation at 0.6 and 0.7%, respectively, during the dry season. For hydronephrosis, Mellau et al. (2011) in Arusha and Tembo and Nonga (2015) in Dodoma, both in Tanzania reported condemnation rate of about 1.9%. Both hydronephrosis and congenital cysts were observed more often in the dry season in these studies, an observation similar to the current study. Water scarcity for animals which is common during the dry season in countries like Botswana and Ethiopia, has been associated with predisposing livestock to renal conditions (Mellau et al., 2010; Tembo and Nonga, 2015). Both Botswana and Tanzania always experience dry seasons, accompanied by low rains, leading to lack of water for livestock. Water scarcity is common is rural poor communities, affecting both humans and livestock watering, with grazing resources also negatively affected by lack of rains. Other high condemnations were reported

Table 3. Overall estimated financial losses over the two seasons due to condemnations of the edible red offals.

Offal	Price/kg[a]	Dry season		Wet season	
		Total offals	Total Money	Total offals	Total Money
Lungs	23.95	1306	31278.70	890	21315.50
Liver	36.95	739	27306.05	552	20396.40
Spleen	23.45	84	1969.80	79	1852.55
Kidney	29.95	80	2396.00	10	299.50
Total			**62950.55**		**43863.95**

[a]USD1.00 ~ BWP11.00 (Exchange rate: USD to Botswana Pula).

in Morocco, Ethiopia and Kenya (Njoroge et al., 2002; Azlaf and Dakkak, 2006; Berhe, 2009), countries that always experience frequent droughts just like Botswana. Variations in prevalence of hydatidosis in cattle may be as a result of differences in the ecosystems, grazing patterns and status of Echinococcosis in stray dogs, which are the definitive hosts (Njoroge et al., 2002). In a study conducted in Wolaita Soddo Municipality Abattoir of Southern Ethiopia, Abunna et al. (2013) reported that kidneys were condemned mainly for unidentified causes (26.7%) and hydatid cysts (64.3%). These were relatively higher condemnations rates for livers compared to the current study. Variations in these findings further points to differences in ecosystems, grazing patterns, herd health strategies and status of Echinococcosis in stray dogs between Botswana and these other countries. In a study conducted by Bogale et al. (2012) at Gondar, Northwest Ethiopia conducted from November 2011 to April 2012 reports show that nephritis and hydatidosis were found to be the major principal causes for kidney condemnation, accounting for 29.4%. Mesfin et al. (2015) reported that in Dessie municipal abattoir North Eastern of Ethiopia that hydro nephrosis was identified as cause for kidneys condemnation at 11(1.4%) followed by hydatidosis 10 (1.3%), Nephritis 8 (1.0%), Calculi 5 (0.7%) and cyst 5 (0.7%).

Estimated financial losses

The condemnation of edible red offals in slaughter facilities leads to financial losses by meat processing industries and loss of animal protein at household level, negatively affecting food security. The current study observed that overall, the slaughter facilities lost revenue amounting to BWP106 814.50 (~9 710.40 USD), between May 2015 and March 2016 (Table 3). The dry season losses were higher at P62 950.55 compared to the wet season at BWP43 863.95. Larger losses were due to condemnations of lungs and livers at BWP52 594.20 and BWP47 702.45 for the dry and wet seasons, respectively. The spleen and kidneys losses were lower than BWP7000.00 collectively (Table 3). Losses of offals due to these condemnations leads to reduced availability of human nutrients (proteins, vitamins and minerals), and deprives farmers and slaughter facilities valuable income. Estimated financial losses in the current study over a total of eight months, were relatively lower than losses reported by Ahmednur et al. (2015) at Dire Dawa Municipal Abattoir, Eastern Ethiopia, where losses associated with condemnation of edible organs were estimated at 109,492,728 Ethiopian Birr (ETB) (~547, 463,60 USD), and those reported by Bogale et al. (2012) at 21,565,849 ETB (1268579 USD) per year at Gondar, Northwest Ethiopia.

In another study by Mesfin et al. (2015), losses were lower and comparable to those of the current study. They reported financial losses of 122,617.70 Ethiopian birr (6,288.08 USD) at Dessie municipal abattoir, North Eastern Ethiopia, losses that were associated to condemnation of edible organs. The differences in financial losses in these studies may be due to the value and pricing of individual organs/offals, and currency strengths between the Botswana pula (BWP) and Ethiopian Birr (ETB). Further, ecological factors, farming practices and herd health efficiencies between Botswana and Ethiopia may be different. Nonetheless, these revenue losses negatively affect the livestock value chain; farmers, meat traders and the livestock industry, retarding socio-economic progress in such communities.

Conclusion

The study has revealed the level of condemnations of red beef offal and related revenue losses in the Kgatleng district of Botswana, just like in other African countries. Dry season had a higher percentage of carcasses with condemned offals compared to the wet season respectively. Of the condemned edible red offals in the two seasons, the dry season had a higher percentage of condemnations of lungs versus the wet season for lungs and livers, respectively. The condemnations rates of both the spleen and kidneys were relatively low and comparable across the two seasons. This study shows that for the lung, the emphysema condition contributed heavily to condemnations in both the dry and wet seasons. Peritonitis condition was the main contributor to liver offal condemnations in the two seasons. Financially, the dry season losses were relatively higher compared to the wet season. Therefore, farmers in the Kgatleng district should put in place proper management and herd health strategies to reduce occurrence of these conditions in carcasses, so as to avail offal products to the market. This will assist abattoirs generate more income from offal products, and cut on financial losses. Furthermore, existence of some of these zoonotic conditions such as tuberculosis, hydatidosis, fasciolosis and cysticercosis in beef herds pose a health hazard to farmers, meat handlers, meat consumers and the public in general under poor herd health farming systems. Thus, livestock extension and public health education need to be strengthened to reduce the disease burden in the Kgatleng veterinary district.

CONFLICT OF INTERESTS

The authors declare no conflict of interest in this study.

ACKNOWLEDGMENT

Authors hereby acknowledge that the Botswana University of Agriculture and Natural Resources (BUAN) and The Ministry of Agriculture and Food Security resources were used in this study.

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