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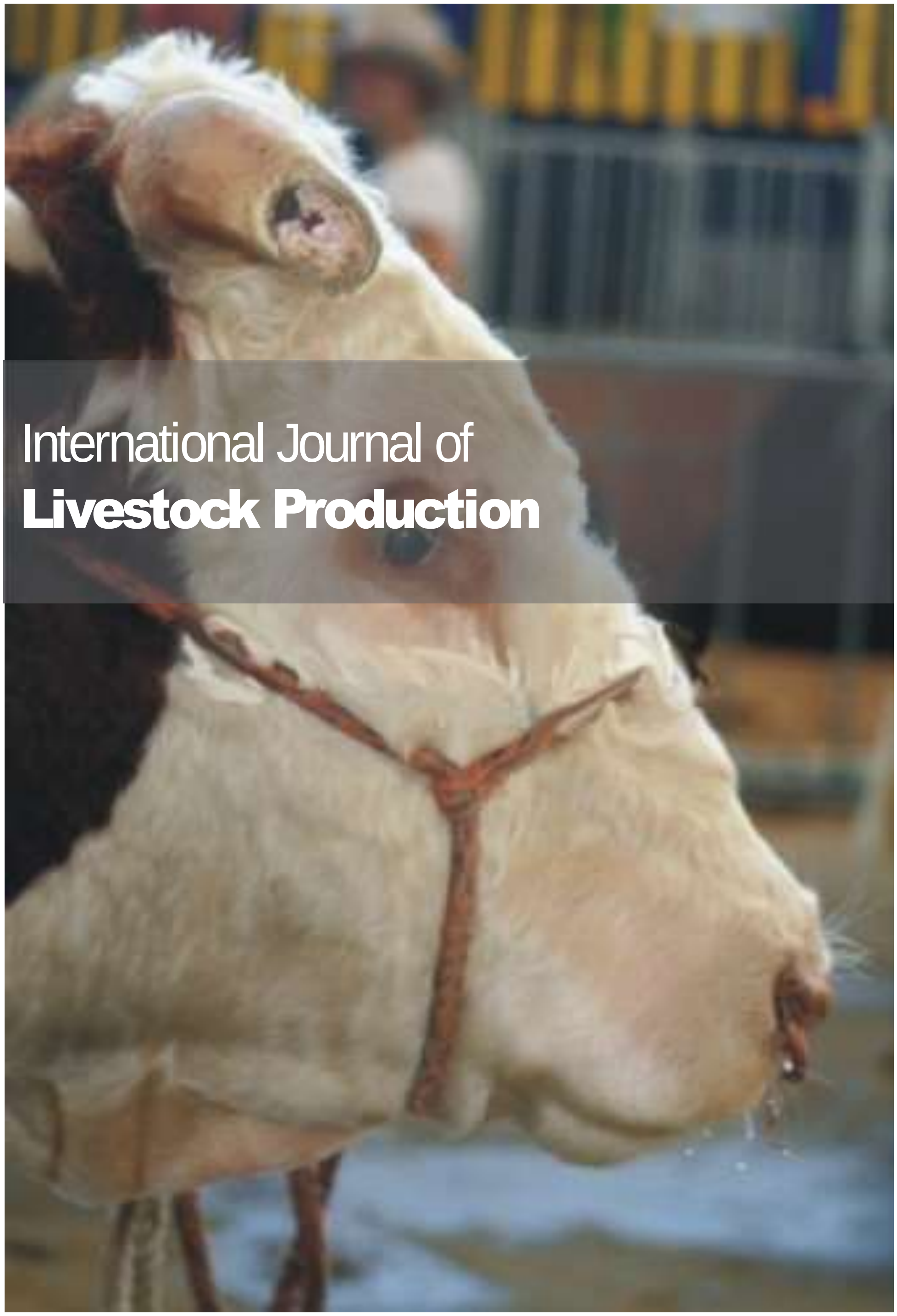

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Review

Productive and reproductive performance of indigenous chickens in Ethiopia

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This study reviews the productive and reproductive performance of indigenous chickens in Ethiopia with the aim of delivering summarized and synthesized information for the beneficiaries and producers. Chicken production encompasses into traditional scavenging, small and large-scale market orientated systems based on the objective of the producer, the type of inputs used and the number and types of chickens kept. In Ethiopia, indigenous chickens produces 10 to 20 eggs per clutch and 30 to 65 small eggs per hen per year in 3 to 4 clutches. Local chickens reach slaughter/market age at 8 to 12 months with 0.6 to 2.5 kg average weight at farmer management system. Indigenous chickens require long time to reach sexual maturity and takes longest time to recover reproductive cycle by local broody hen. The average mortality rate was highest and which affects both productive and reproductive performance of indigenous chickens by reducing survival rate. There were huge number of indigenous chickens existing in Ethiopia but productivity was disproportional to the number of chickens. The major constraint which affects productive and reproductive performance of indigenous chickens are diseases and predators, feed shortages, lack of training and extension services, and lack of proper marketing systems. Conclusively, lowest productive and reproductive performance was recorded which needs further improvement by adjusting training and extension service for farmers.

Key words: Indigenous chickens, reproductive performance, productive performance, Ethiopia.

INTRODUCTION

Poultry production is an important sector in Ethiopia where chickens and their products are important sources for income generation for rural peoples and important source for high quality protein for developing countries. Poultry in Ethiopia is similar with chicken and total chicken population were 60.5 million, from 94.33, 2.47 and 3.21% were indigenous, exotic and hybrid chickens, respectively (CSA, 2016). Backyard poultry production in Ethiopia represents a significant part of the national economy in general and the rural economy in particular which contributes 83.5% of the national egg and meat products (CSA, 2016).

Chicken production encompasses into traditional scavenging, small and large-scale market orientated sectors which is based on the objective of the producer, the type of inputs used and the number and types of

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chickens kept (Halima, 2007). The rural poultry sector constitutes about 98% of the total chicken population (FAO, 2007) and largely consists of the indigenous or native domestic fowl. The traditional back yard system are characterized by mainly low-input and small-scale with 4 to 10 mature birds per household, reared in the back yards with inadequate housing, feeding and health care. Scavenging is the most important component of the poultry diet (Fisseha et al., 2010; Meseret, 2010).

The Ethiopian indigenous chickens are known to possess desirable characters such as thermo tolerant, resistance to some disease, good egg and meat flavor, hard egg shells, high fertility and hatchability as well as high dressing percentage (Aberra, 2000). According to Abubakar et al. (2007) the impact of the Ethiopian village chicken in the national economy and its role in improving the nutritional status, family income, food security and livelihood of many smallholders is significant owing to its low cost of production. The diverse agro-ecology and agronomic practice prevailing in the country together with the huge population of livestock in general and poultry in particular, could be a promising attribute to boost up the sector and increase its contribution to the total agricultural output as well as to improve the living standards of the poor livestock keepers (Aleme and Mitiku, 2015; Hunduma et al., 2010).

The Ethiopian indigenous chickens are none descriptive breeds closely related to the jungle fowl and vary in color, comb type, body conformation, weight and may or may not possess shank feather and broodiness is pronounced (Demeke, 2008). The mean annual egg production of indigenous chickens is estimated to be 60 small-size eggs per year with a thick shell and deep yellow yolk color. Indigenous chickens are poor in productive and reproductive performance which are characterized by small sized eggs, slow growth rate, late maturity, slow age at first mating, small clutch size, a natural learning to broodiness and high mortality of chicks among the flock. Low productivity of indigenous chickens is due to low hatchability and high mortality of chicks (Fissaha et al., 2010; Getachew and Negassi, 2016).

There were huge number of indigenous chickens in Ethiopia but its productive and reproductive performance were low and varies in different area, and are not reviewed and well documented for users and producers. There is a need for reviewing the productive and reproductive performance of village chickens to improve the indigenous chicken productivity and to save the indigenous genotype from distinction or replacement by exotic chickens. This being the cases, the objective of this review is to review the productive and reproductive performance of indigenous chickens in Ethiopia with the following specific objectives:

1. To review the productive performance of indigenous chickens in Ethiopia
2. To review the reproductive performance of indigenous chickens in Ethiopia
3. To review the constraints that affects productive and reproductive performance of indigenous chicken in Ethiopia

LITERATURE REVIEW

Productive performance of village chickens

The productive performance of indigenous chickens are low, which includes clutch number, average number of eggs laid per clutch, average days per clutch, average number of eggs per hen per year, slaughter age and weight of chickens.

Clutch number

Clutch numbers of Ethiopian indigenous chicken is different at different production and management systems. According to CSA (2016) report the national average clutch number of Ethiopia indigenous chicken was 4 per year. The number of clutch periods showed by local hens per year is 3.8, 2-6 and 3.7 in Bure, Fogéra and Dale, respectively (Fissaha et al., 2010). According to Melkamu and Wube (2013) in Debsan, Tikara and Kebele at Gonder, Zuria and Woreda the average clutch number were 3 per year. Alem (2014) reports in Central Tigray, the average clutch number per year were 3.15 to 3.2 and 3.2 at lowland and midland agro-ecologies, respectively.

The number of clutch periods recorded per year was 4.29±0.17 (range 3.38 to 6.11) in Metekel zone of Northwest Ethiopia, respectively (Solomon et al., 2013). The average number of clutches per year per hen was 3.2 for local hens ranged from 2 to 5 with an average clutch length of 21.6 days, ranged from 15 to 28 days in lowland and midland agro-ecological zones of Central Tigray (Alem, 2014). The average number of clutches per year recorded from the Gomma Wereda was 3.43 (Meseret, 2010). The overall average clutch number of chicken in North Wollo of Amhara region was 3.62 per year (Addisu et al., 2013). Mekonnen (2007) reported that the mean clutch number of indigenous chicken in three districts of SNNPRs was 3.8 per year.

Egg production

Indigenous chickens' produces lowest number of eggs and is small in size. An indigenous chicken in Ethiopia produces 12 eggs per clutch (CSA, 2016). According to Yadessa et al. (2017) finding indigenous chickens produces 14.3 small eggs per clutch in Mezhenger, Sheka and Benchi -Maji zones of south western Ethiopia. Solomon et al. (2013) report under existing farmer management condition, number of eggs produced per clutch was 13.56±0.26 in Metekel zone of Northwest Ethiopia. Addisi et al. (2013) reported that, average eggs laid/clutch/hens was 16.88, 14.23 and 11.9 eggs in Quara, Alefa and Tach Annachiho districts, respectively. Average number of eggs laid per hen per clutch was 13.6 for local hens which ranged from 9 to18 eggs in lowland and midland agro-ecological zones of Central Tigray (Alem, 2014). The average number of eggs per clutch of indigenous chickens reported from Gomma district was 12.92 (Meseret, 2010).

Egg production potential of local chicken is 30 to 60 eggs/year/hen, with an average of 38 g egg weight under village management conditions while exotic breeds produce around 250 eggs/year/hen with 60 g egg weight in Ethiopia (Alganesh et al., 2003). Indigenous chickens produce 48 small eggs per hen per year at farmers' management conditions in Ethiopia (CSA, 2016). The average number of eggs produced per hen per year was 54.5 in Mezhenger, Sheka and Benchi -Maji zones of south western Ethiopia (Yadessa et al., 2017).

According to Addisu et al. (2013) 49.51 eggs per hen per year was reported from North Wollo, Amhara Region, Ethiopia. Solomon et al. (2013) also reported 59.5 eggs per hen per year in Metekel zone, Northwest Ethiopia. According to Fissaha et al. (2010) finding, the total egg production/hen per year of local hens under farmer management condition is estimated to be 60, 53 and 55 in Bure, Fogéra and Dale woredas, respectively. Melkamu (2014) finding showed that an indigenous chicken produces average of 65 eggs per hen per year. Indigenous chickens produce 59.51±2.66 (range 45.38 to 93.19) per hen per year in Metekel zone of Northwest Ethiopia (Solomon et al., 2013). Mean annual egg production of the indigenous chickens of Gomma Wereda was 43.8 eggs (Meseret, 2010), mean annual number of eggs produced from Dale district was 55.2 eggs/year/hen (Mekonnen 2007) and average number of eggs per hen per year in Ambo was 36 to 42 (Fikre, 2000). The mean annual egg production/hen in North Wollo of Amhara region was 49.51 ± 0.38 (Addisi et al., 2013).

Slaughter weight of indigenous chickens

Bogale (2008) indicated that the meat production ability and growth performance of indigenous chicken are limited and the local males reach 1.5 kg live weight at 6 months of age and females of about 30% less. According to Gain (2017), local Ethiopian chickens 1.25 kg are in slaughter village management condition. The average weight of mature males (cocks) was significantly higher in midland (1.812) kg than in lowland (1.694) agro-ecology in Central Tigray. But, similar body weight of hens (1.37 and 1.356 kg), cockerels (1.024 and 1.119 kg) and pullets (1.021 and 1.064 kg) was recorded in lowland and midland agro ecology, respectively. These significant differences in body weight of indigenous chickens were attributed to non-genetic factors like supplementary feeding, watering and health care in different agro-ecology of Centeral Tigray (Alem, 2014).

According to Meseret (2010) finding the mean market weight of indigenous male chickens in Gomma wereda was 1.5 kg at 8.62 months in village management condition. Mekonnen (2007) reported that the mature body weight of cocks and hens at farmers management condition in Wonsho, Loka abaya and Dale districts of Southern Ethiopia were 1.58 and 1.30 kg, respectively. The average weight of local hens ranges from 0.6 to 2.1kg and local cocks ranges from 0.6 to 2.5kg at selected districts of North Western Amhara region.

Slaughter/Market age of indigenous chickens

According to Gain (2017) report Ethiopian indigenous chickens reach slaughter at the age of 8 to 12 months in village management system. Mean age at slaughter for indigenous male chickens of Gomma Wereda was 8.62 months (Meseret, 2010). Getiso et al. (2017) reported that in three agro-ecologies of SNNPR, indigenous chickens reach slaughter at 9.9 months. Also in western, Tigray indigenous chickens reach slaughter at 4.66 and 4.5 months for male and female chickens, respectively (Shishay et al., 2015).

In other hand, indigenous male chickens of Wolaita zones in southern Ethiopia requires 8.6, 9.4 and 8.9 months to reach slaughter at highland, midland and lowland areas, respectively (Zereu and Lijalem, 2016).

Reproductive performance of village chickens

Reproductive cycle takes longest time for indigenous chickens because they require long time to reach sexual maturity age and replace parent stock by traditional broody hens which require long time to recover the reproductive cycle.

Age at sexual maturity of indigenous chickens

The overall mean age of cock at first mating was 4.9 months in Mezhenger and Sheka but in benchi-Maji zone it requires 5.2 months (Yadessa et al., 2017). Meseret (2010) reported that the mean sexual maturity of indigenous chicken at Gomma district of Jimma zone were about 6.33 months.

According to Aberra et al. (2013) report, age at first egg of scavenging chickens in different agro-ecological zones of Amhara region was 6.6 months. The average age of indigenous pullets and cockerels at first mating was 5.2±1.16 and 5.44±1.3 months in Metekel zone of Northwest Ethiopia, respectively (Solomon et al., 2013).

Average age at first egg was 27.2 weeks for local breeds ranged from 24 to 28 weeks and average age at first mating of cockerels was 26 weeks for local chickens in lowland and midland agro-ecological zones of Central Tigray (Alem, 2014). Mekonnen (2007) reported that, age at first egg was 7.07 months for indigenous pullets of Dale wereda. The overall mean age of sexual maturity was 24.25 ± 0.04 and 23.84 ± 0.05 weeks for indigenous male and female chickens in North Wollo of Amhara Region, respectively (Addisu et al., 2013). In Bogale (2008) finding, the mean age of sexual maturity of indigenous chicken in Fogera district was 23.48 ± 0.1 and 23.6 ± 0.11 weeks for male and female, respectively.

Hatchability of indigenous chickens

Natural incubation is the most commonly used method for replacing and increasing the size of flocks by the help of broody hens. Incubating hens uses dark and quite place for laying and incubating eggs. Producers adjust appropriate place and makes nest for broody hens which uses clay pot and straw bedding (cartoons) but in some cases uses clay without bedding (broken pot). Farmers are very conscious and concerned for preparation of appropriate place which provide good feed resources and best environment for incubating by broody hens. Traditionally, farmers incubate at dry season and uses eggs which were laid within the houses (Bikila, 2013).

The average number of eggs incubated per hen in different agro-ecological zones of Amhara region was 12.8 and out of the incubated eggs, only 10 chicks were hatched, giving an average hatchability of 79.1% (Aberra et al., 2013). According to Solomon et al. (2013) report the average number of eggs set per hen was 14.74±0.25 (range 12.40 to 16.91) with a hatchability of 84.7% in Metekel zone of Northwest Ethiopia. According to Fissaha et al. (2010) report, 13 eggs (ranged 7 to 22) have hatchability percentage of 82.6 and 89.1 at Bure and Dale districts of Ethiopia, respectively. According to Alem (2014) report in both agro-ecologies of the Central Tigray the average numbers of eggs set for incubation per broody hen were 10.2 eggs with hatchability of 85.8% for local eggs.

The number of eggs set per hen depends on availability of eggs, size of eggs and size of broody hen and the maternal instinct of the broody hen. However, the overall mean number of eggs incubated was 11.32 eggs with minimum of 6 and maximum 20 eggs per hen and the percent hatchability was 82.74% in Nole Kabba Woreda and Western Wollega, Ethiopia (Habte et al., 2013). The mean percent total hatchability calculated for the indigenous chickens of the Gomma Wereda was 22% (Meseret, 2010). The Average number of eggs set for incubation was 13 ranging from 10 to 20 per hen from which relatively fair number (83%) chicks were hatched in East Gojam zone of Amhara regional state (Melese and Melkamu, 2014). Samson and Endalew (2010) reported that, productive indigenous hens lay on average 10 to18 eggs per clutch and 7 to15 eggs were incubated using a broody hen from the incubated eggs 5 to10 chicks hatched per clutch.

Mortality and survival rate of indigenous chickens

Scavenging system is characterized by high chick mortality in the first two weeks of life, caused mainly by predators and Newcastle disease in Southern region of Ethiopia (Melesse and Negesse, 2011).

According to Alganesh et al. (2003) and Negussie et al. (2003) the low productivity of the local scavenging hens is not only because they are low producers of small sized eggs and slow growers but also the system is characterized by high chick mortality before they reach around 8 weeks of age. In different agro-ecological zones of Ethiopia at Amhara region, 10 chicks were hatched and among these only 5.5 chicks reached market age, which implies 58.3% survival rate suggesting high chick mortality during the growing period (Aberra et al., 2013). Chicks which reached grower stage 8 weeks (survival rate) were 65.8% for local chickens in lowland and midland agro-ecological zones of Central Tigray (Alem, 2014). According to Tadelle et al. (2003) finding, average survival rate of chicks in Ethiopia was 51.3% and about 44.2% mortality of chicks (55.8% survived) was reported by Abraham and Yayneshet (2010) from Northern Ethiopia. Mean chick mortality (to an age of 8 weeks) of indigenous chickens of Gomma Wereda was 41% (Meseret, 2010) and the mean number of chicks which survives to market age in East Gojam zone of Amhara region was 65.91% (Melese and Melkamu, 2014).

Constraints of indigenous chicken production

Disease and predators

Disease and predator were the main constraints of indigenous chicken production at farmer management condition in Lemo district of Hadiya zone in southern Ethiopia (Salo et al., 2016). Halima (2007) reported that, diseases and predator were the major factor that causes loss of chicken in Northwest Ethiopia. Shishay et al. (2014) revealed that, both diseases and predators have highly prevalent challenges which hinder indigenous chicken productivity. According to their report Newcastle disease (1st), fowl salmonella (2nd), coccidiosis (3rd), fowl typhoid (4th), fowl cholera (5th), fowl pox (6th) and fowl coryza (7th) were the major and economically important diseases that hinder the expansion of village chicken production in Western Zone of Tigray, Northern Ethiopia.

Fentie et al. (2013) also, recently reported that poor health care, incidence of predation, poor housing and feeding management were the major constraints of village chicken production of which, poultry diseases (46.2%) and predation (27.1%) were the most predominant causes of chicken loss. New castle disease was the biggest constraints of family chicken production in North Gondar of Northwest Ethiopia. Diseases and predators were the first and second major constraints that cause loss of chickens in North West Ethiopia (Halima, 2007). A study conducted in Mekele zone of North West Ethiopia also revealed that, seasonal outbreak of diseases and predators were major factors that cause loss of chickens, and lack of credit services, limited skill of management practices and low productivity of local chickens were outlined as major constraints of chicken production (Solomon et al., 2013). The most serious constraint hindering poultry production is predator and poor housing system and the scavenging feeding system of poultry leads for this problem in Arbegona Woreda of Sidama Zone in Southern Ethiopia (Feleke et al., 2015). The most important constraints impairing the existing chicken production system under farmer's management condition in their order of significance were disease, lack of veterinary health service, traditional management system with limited feed supplementation, poor housing and no access of improved breeds with limitation of extension service (Melese and Melkamu, 2014).

Feed shortage

Bogale (2007) reported that, shortage of supplementary feed (19.4%) was the main constraint which hinders indigenous chicken productivity in Fogera district. There is no purposeful feeding of chickens under the village conditions in Ethiopia and scavenging is almost the only source of diet. Scavenging feed resource base for local birds are inadequate and the main constraints in Fogera district (Bogale, 2008). Scavenge feed resources are defined as the total amount of feed products available to all scavenging animals in a given area. It depends on the number of households, the type of crop grown and crop processing as well as climatic conditions (Sonaiya and Swan, 2004).

The local birds in the farming community are allowed to wander freely inside and outside the house in search of the food. Anything in and around the house is used as the most important part of their diet. So, the important sources of the feed for bird are household wastes, anything from the environment and small amount of grain thought to be useful sources of nutrition (Meseret, 2010). The local chickens in the farming community are allowed to wander freely inside and outside the house in search of the food. So the important sources of the feed for bird are household wastes, anything from the environment and small amount of grain thought to be useful sources of nutrition (Resource-Centre, 2005).

Marketing system

There is no formal poultry and poultry product marketing channel and informal marketing of live birds and eggs involving open markets are common throughout the Woreda, which affects production of indigenous chickens in Haramaya (Abera and Geta, 2014). Fluctuation (seasonality) in prices of chicken products was the most prevailing chicken and egg marketing constraint (Bikila, 2013). The major constraints in rural chicken marketing were identified as low price, low marketing output and long distance to reliable markets. As a result, the smallholder farmers are not in position to get the expected return from the sale of chickens in North West Ethiopia (Awol, 2010).

Seasonal fluctuation of chicken and eggs, low supply (output) of chickens and eggs due to disease and predation, presence of limited market outlets and lack of space for chicken marketing in urban area were market related constraints which affects poultry production (Moges et al., 2010).

Lack of training and extension service

There was low extension support from responsible bodies to improve indigenous chicken production in Eastern Ethiopia (Getachew et al., 2015). According to Bikila (2013), low supply of exotic breed and limited credit for poultry production, weak extension service, lack of appropriate chicken and egg marketing information to producer farmer and lack of enough space for chicken marketing in urban markets were the major challenges which hinders indigenous chicken productivity. The extension linkage between the research output and the ministry of agriculture and the farmers are found to be extremely weak, thus in general there is no consistent feedback to the research. Fisseha et al. (2007) also reported that, lack of access to extension agents for chicken farmers is one of the main reasons for the lower extension service in Burie district of Amhara region.

Lack of access to get extension agents was the main reason (31.8%) for absence of extension service with regard to village chicken production. Lack of modern poultry rearing knowledge through extension service and training was the other constraint in both districts of Ethiopia (Fissaha et al., 2010). It is also reported that training for both farmers and extension staff focusing on disease control, improved housing, feeding, marketing and entrepreneurship could help to improve productivity of local chicken (Moges et al., 2010).

CONCLUSION AND RECOMMENDATIONS

Chicken production system encompasses into traditional, small and large-scale market oriented production system based on the objectives of the producers, the type of inputs used and type and number of chickens reared. Traditional production system is characterized by low-input and small-scale with 4 to 10 mature birds per households with inadequate housing, feeding and health care practice. The productive performances of indigenous chickens are low in village management condition (inappropriate feeding, housing and health care practice).

In Ethiopia, indigenous chickens produces 10 to 20 eggs per clutch and 30 to 65 small eggs per hen per year was laid in 3 to 4 clutches. Local chickens reach slaughter/market age at 8 to 12 months with 0.6 to 2.5kg average live weight at farmer management condition. Indigenous chickens require long time to reach sexual maturity and takes longest time to recover reproductive cycle by local broody hen.

Chickens take 5 to 7.2 months to reach first mating and egg lying age. They reproduce by natural incubation system by broody hen with the average hatchability of 75 to 85%. The average mortality rate was highest, which affects both productive and reproductive performance of indigenous chickens by reducing survival rate. There were huge number of indigenous chickens existing in Ethiopia but productivity was disproportional to the number of chickens. The major constraints which affects productive and reproductive performance of indigenous chickens includes diseases and predators, feed shortages, lack of training and extension services, and lack of proper marketing systems.

Depending on the above conclusions, the following recommendations were needed to improve productive and reproductive performance of indigenous chickens.

1. Farmers should improve management conditions (feeding, housing and health care practice).
2. Government should adjust training and extension service to improve this sector.
3. Government should adjust proper market channel to solve input-output marketing challenges.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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Review

Current Status of animal biotechnology and option for improvement of animal reproduction in Asia

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The aim of this review paper was to investigate the use of biotechnology in the improvement of animal reproduction in different Asian Countries. Biotechnologies have contributed immensely to increasing livestock reproductively, particularly in developed countries, and can help to alleviate poverty and hunger, reduce the threats of diseases and ensure environmental sustainability in developing countries. A wide range of biotechnologies are available and have already been used in different Asian countries in the main animal science disciplines, that is animal reproduction, genetics and breeding; animal nutrition and production; and animal health. In animal reproduction, genetics and breeding, artificial insemination (AI) has perhaps been the most widely applied animal biotechnology, particularly in combination with cryopreservation, allowing significant genetic improvement for productivity as well as the global dissemination of selected male germ plasm. Complementary technologies such as semen sexing can improve the efficiency of AI. Embryo transfer provides the same opportunities for females, albeit on a much smaller scale and at a much greater price. Molecular DNA markers can also be used for genetic improvement through marker assisted selection (MAS) as well as to characterize and conserve animal genetic resources. Specific options that should assist Asian countries make informed decisions regarding the adoption of appropriate biotechnologies in the livestock sector in the future.

Key words: Animal biotechnology, Asian countries, Reproduction.

INTRODUCTION

A major benefit of agricultural research and technology is that the purchasing power of the poor increases, because both average incomes and access to staple food products are improved and will lead to a distinct shift in the economic returns from livestock. Agricultural biotechnology has the potential to address some of the problems of developing countries like food insecurity, unfavorable environmental and climatic conditions, etc mentioned above and also improve agricultural productivity; one of the methods that are believed to accelerate maintaining the livestock production is the use and application of reproductive biotechnology in a wide range of and/or intensively to the producers/farmers. Kahi and Rewe (2008) stated that biotechnology is important if the world is to respond to the pressure to produce more food from livestock animals according to the ever-growing human population.

Furthermore, it was suggested that biotechnological approaches can be employed for improving productivity, economy, and physicochemical and nutritional attributes of a wide range of livestock products (Gupta and Savalia, 2012).

The use of reproductive biotechnologies especially artificial insemination (AI) and embryo transfer (ET) in

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cattle industry has widely been applied in many farms in developed countries. Since these reproductive biotechnologies were found to improve genetics and production of livestock animals, these were spread out rapidly and slowly to all over the world both in developed and developing countries and Indonesia is no exception. In Indonesia, as one of developing countries, the use of these biotechnologies face a challenge to increase the productivity of animals especially for beef production to meet the need for food as human population increases rapidly (Anonymous, 2009). Madan (2005) reported that the developing world is grossly unprepared for the new technological and economic opportunities, challenges, and risks that lie on the horizon. Moreover, he mentioned that livestock production is globally growing faster than any other sectors and by 2020 livestock is predicted to become the most important agricultural sector in terms of value adding and that the role of biotechnology will lead to a distinct shift in the economic returns from livestock. Therefore, it is necessary to establish and to apply the biotechnology, especially reproductive biotechnology, to meet the challenges in livestock animal and beef production for the need of human population.

Globally, livestock production is growing faster than any other sector, and by 2020 livestock is predicted to become the most important agricultural sector in terms of added value. Although it is hoped that biotechnology will improve the life of every person in the world and allow more sustainable living, crucial decisions may be dictated by commercial considerations and the socioeconomic goals that society considers to be the most important. There has been a constant increase in the demand of livestock and livestock related products worldwide. However, today the world production merely meets the demand to a significant extent. No wonder this has made scientists to try to improve livestock and livestock associated derivatives. With genetic manipulation and related technologies gaining prominence more and more research interests to improve livestock using genetic engineering has become a buzzword today; day by day more focuses are being put in this regard (Onteru et al., 2010).

There is also active competition for new technologies that may directly or indirectly affect the future of animal production, including breeding. Some non-European countries (New Zealand, the USA, Argentina, Brazil, China) are rapidly developing research on and in some cases implementation of new reproduction and cloning technologies (somatic cell nuclear transfer, that is “Dolly-type” cloning) and genetically modified animals. Other fore seen applications of the new biotechnologies in animals are in the medical field: animal models, animals as bioreactors, and animals for xenotransplantation. Although the development and possible use of such applications are beyond the direct scope of breeding organizations, Europe must be in a position to objectively evaluate these technologies and consider their potential (Anne et al., 2006).

Both Asia and Europe are densely populated and have comparatively little land available for agriculture. In contrast, the Americas (and Oceania) have relatively large amounts of arable land and pasture as compared to population density. This creates for Europe and Asia a permanent risk of food dependence on the Americas. It also creates a ‘natural’ push to develop foods and food products for –and sell them to- the more denselypopulated areas. Related policies include farmingsubsidies in the USA, stimulation of genomics and biotechnology research, and a favorable business and social climate for developing and implementing new technologies.

Among the animal biotechnologies, the most widely used ones in the region are the application of assisted reproductive biotechnologies such as artificial insemination (AI), estrous synchronization and embryo transfer. In animal health, molecular based serological techniques using monoclonal antibodies and recombinant antigens as well as PCR based methods are being used for diagnosis of diseases and epidemiological studies in most countries, together with conventional and recombinant vaccines for controlling diseases (FAO, 2009).

Molecular markers for genetic diversity studies are also used widely, but marker assisted selection for genetic improvement is only being used in a few of the more developed countries. Biotechnologies to improve animal nutrition through feed additives such as amino acids and enzymes are widely applied, especially in monogastric livestock, whereas use of other additives such as prebiotics and probiotics is less common. Advanced technologies such as cloning and transgenesis are hardly used in most countries of the region, as they currently have limitations in success rates and cost-effectiveness, as well as ethical, religious and animal welfare concerns. The species of animals on which these biotechnologies are used in the region include cattle, buffalo, sheep, goats, pigs, horses, camels, deer, chicken, ducks, quails, guinea fowl and fish (Anne et al., 2006).

Therefore the objective of this review paper was to investigate the use of biotechnology in the improvement of animal Reproduction in different Asian Countries and attempts to highlight pros and cons, on the recent developments in reproductive biotechnologies both in male and female in livestock species.

ANIMAL BIOTECHNOLOGY DEFINITIONS AND HISTORICAL PERSPECTIVE

Ramli-Bin et al. (2011) defined the term “Animal biotechnology” as the application of scientific and engineering principles to the processing or production of materials by animals or aquatic species to provide goods and services for the wellbeing of human population.

Biotechnology has been practiced since the beginning of animal husbandry (FAO, 2011). The evaluation and selection of different breeds started with the domestication of animal species around 12000 years ago which was led by the wish to obtain traits dictated by social, nutritional and environmental needs with no understanding of the molecular processes involved (FAO, 2011).

The Asia Reproductive Biotechnology Society was established in 2004 to promote the educational and scientific interests of the reproductive biotechnology research community throughout Asia. The society includes active scientists and students working in many Asian countries, including Japan, South Korea, China, Vietnam, Thailand, Indonesia, Malaysia, India, Singapore, Bangladesh, Taiwan, Laos and Cambodia, Iran, Mongolia, Brunei, United Arab Emirates (UAE), etc. and serves as the region's premiere forum for scientific discussion and exchange in this field (ARBS, 2014).

The main objectives of using reproductive biotechnologies in livestock are to increase production, reproductive efficiency and rates of genetic improvement. Over the years, many options have become available for managing the reproduction of the major large and small ruminants. Artificial insemination (AI) and preservation of semen are the main technologies that are used extensively. Reproductive technologies can also be used to control reproductive diseases if procedures and protocols are accurately followed (Madan, 2002).

Current status of application of animal biotechnology in Asia

In recent times, reproductive biotechnologies have emerged and started to replace the conventional techniques. It is noteworthy that for sustained livestock productivity, it is imperative to start using these techniques for facing the increasing challenges for productivity, reproduction and health with impending environment conditions. These recent bio-techniques, both in male and female, have revolutionized and opened avenues for studying and manipulating the reproductive process both *in vitro* and *in vivo* in various livestock species for improving its efficiency (Garner, 2001).

Semen sexing and artificial insemination in Asian countries

Another reproductive biotechnology that is now developing in Indonesia is sexing of semen for AI. Lembang AI station has produced 2,511 straws of sexed semen which consisted of 1,302, 719, and 490 straws (FH, Simmental and Limousine, respectively) in 2013. Similarly, Singosari AI station has also produced 2,100 X-bearing sperm of FH in 2012. However, we have no data regarding the fate of this sexed semen especially their contribution on reproductive performance of the cows after AI. Nevertheless, a study using sexed semen in Bali cattle has been reported by Said et al. (2014); the overall conception rate after AI in their study was 59.2% (148/250). This technology is used for producing offspring of the desired sex, either male or female. Selecting the sex of the progeny using sex-sorted sperm has been an advantage for animal breeders (Johnson, 2000; Seidel, 2014).

This technique works on the principle of flow cytometric separation of fluorescent-labeled X-chromosome bearing spermatozoa from the sperms carrying fluorescent labeled Y-chromosome. At present, this technology is capable of analyzing over 100,000 events(sperms) per second and can sort 70,000 events (sperms) per second. By this way, it is capable of sorting 15 million spermatozoa per hour into X- and Y- bearing sperms (Garner,2006) and accuracy of predicting the sex of calves is between 85 and 95% (Garner, 2011).

This technique has been used in various domestic species including buffaloes (Campanile et al., 2011; Gaviraghi et al., 2013; Warriach et al., 2015). Although the number of sorted sperm tends to be low, acceptable pregnancy rates have been obtained by *in vivo* deep intrauterine insemination (Blondin et al., 2009; Carvalho et al., 2010). In addition, semen sexing can be used for enhancing progeny testing program, increase breeding male production, reduce the incidence of sex-linked diseases, besides conservation ofsuperior and rare animals. One of the main limitations of this technique is the low number of sexed sperm produced per unit of time, and sexed sperm display a variety of damages, *viz*., destabilization of sperm membrane and capacitating-like changes there by reducing lifespan of sorted spermatozoa in the female genital tract (Gosálvez et al., 2011a; Gosálvez et al., 2011b).

Semen production in Asia countries

In Thailand, the large scale application of AI has been playing a key role in livestock improvement, especially in dairy cattle, beef cattle and buffalo. This technique is largely developed due to the promise of economic advantage. Cattle semen production is carried out in two main sectors: offered by Department of Livestock Development and private companies. Previously, Hariana and Brahman were imported to Cambodia of South East Asian since 1950 (Maclean, 1998), and widely spread in 1980 through the artificial insemination technique (Maclean, 1998; Soun, 2003). Nowadays, however, semen production and artificial insemination are rarely to be applied in ruminant, and it becomes a preferable practice in commercial pig farms. According to MAFF (2014), the animal breeds are increasingly improved according to the national policy and strategy of animal health and production, and they are promoted by import of genetic materials, selections of local breeds with high productivity in order to extend animal breeds to farmers and private farmers within countryside as well.

Concerning the use of AI technologies, there are no formal reports on the number of cow inseminated by official technicians. However, it is assumed that only very small numbers of cows were accepted the AI technologies according to the number of imported frozen semen straws used and the available straws comparing with the number of cattle population. Most of cattle breeding is done by natural mating only which is generally expensive and time consuming (varies from 100,000 150,000 Riels per conception, and the farmers have to bring their heated cows to the house of bull's owners). On the other hand, AI services are usually unavailable and not cheap because of limited frozen semen straws, inseminators, high cost ofliquid nitrogen (20,000 Riels per litre), etc. Consequently, farmers have to pay similar price or more per service compared to natural mating (Oudom, 2014).

Embryo transfer technology (ETT)

ETT is an important tool to improve livestock at faster rate as well as provides an opportunity to utilize the genetic contribution of both male and female (Mapletoft, 2013; Hasler, 2014). ETT involves super ovulation, an important step for increasing the number of ocyte from superior donors (Mapletoft, 1985). The transfer of mammalian embryos was first achieved by Walter Heape in 1890. Subsequently, progress in embryo transfer has been reported in various domestic species (Hasler, 2003; Hasler, 1998; Drost et al., 1976). The birth of the first calf through embryo transfer was achieved by Betteridge (Betteridge, 2006). Although super ovulation in buffalo started three decades ago the first live calves from bubaline embryos were born in1983 in the USA and later in India (Purohit et al., 2003). Studies on superovulation among buffaloes have been carried outboth in the river and swamp buffaloes in various countries including India (Nandi et al., 2002).

In most of South East Asian Countries (Combodia, Lao) the reproductive biotechnologies such as synchronization embryo transfer and cloning have never existed and do not have national policy. Regarding ET techniques, there were few officers from DAHP participated in training in Japan many years ago. But because of lack of laboratory equipment and finance constraints on application of advanced reproduction biotechnologies in animals, acquisition of human resources and proper equipment needed for them to improve livestock production, it has never been practical in this country Lao PDR. (Khampasong, 2014).

ET is still at developing stage in Lao PDR. The participation of embryos and technical manpower in ET is still experimental and no other biotechnologies have been carried out in Lao hopefully; this second generation of reproductive biotechnologies will be put into a plan and applied in the near future when dairy production will promote them (Oudom, 2014). Similarly, in Other Asian Countries such as Thailand, bovine embryo transfer has been under developing stage because of the lack of awareness among farmers and unavailability of embryo and technical manpower. Thus, bovine embryo transfer is still at the experimental stages. No progress has been made in the field of embryo transfer in other species in Thailand (Virapol and Nonthasak, 2010).

In vivo production of embryo

In vivo production of embryos in buffaloes resulted in considerable interest with the first river buffalo calf being produced in USA then in India and next in South East Asia country in Philippines. Earlier attempts were reported from South East Asia (Thailand) and Bulgaria with modest results due to peculiarities inherent to the buffalo. Multiple Ovulation and Embryo transfer (MOET) optimizes the female contribution to genetic progress and it increases genetic gain by 63 to 70% per year from juvenile and adult buffalo compared to progeny testing (Purohit et al., 2003). The *in vivo* procedures involve induction of multiple ovulation, breeding and non-surgical recovery of embryos which are then transferred to synchronized recipients

Inherently poor reproduction and seasonality in buffalo warrants the use of advanced reproductive technologies in this species. Efforts at multiple ovulation and embryo transfer in buffaloes have resulted in the birth of calves in many countries by transfer of fresh (Zhang et al., 2011) or cryopreserved embryos, however, the efficiency in terms of super ovulatory response and recovery of transferrable embryos continue to be low. Attempts to improve the ovulatory responses in buffaloes have shown marginal improvements (Tasripoo et al., 2014).

In vitro production of embryos appeared as a valid alternative to *in vivo* recovery of embryos. Attempts to produce embryos from follicular oocytes by *in vitro* maturation, *in vitro* fertilization and *in vitro* culture were successful and resulted in the birth of river (Kandil et al., 2014) and crossbred (50:50 river: swamp) buffalo calves (Jain et al., 2011). Cryopreserved *in vitro* produced embryos also resulted in the birth of river and swamp buffalo calves, including twins (Zhang et al., 2011). Embryos have also been produced in *vitro* by fertilization of oocytes using density gradient prepared or sex selected sperm (Tasripoo et al., 2014). Experiments on techniques such as cloning and embryo splitting (Jain et al., 2011) have been successful in buffaloes, although the overall efficiency still needs considerable improvement.

The use and application stems from the desire to facilitate the genetic improvement program, the production of purebred animals in swamp buffalo dominated countries, and preserve endangered buffalo species like the Tamaraw (Bllballls bllbalis milldorollellsis).

The advanced reproductive techniques that can be applied to male and female water buffaloes are oriented towards genetic improvement, conservation and transgenesis (Jain et al., 2011).

Cryopreservation

Cryopreservation is a process where cells are preserved by cooling to low sub-zero temperatures allowing transportation, long-term storage, conservation, and programmed utilization. This technology is important for the cryo banking of animal's germplasm from endangered species and exploitation of genetically superior sires through AI and embryo transfer. Cryopreservation of sperm is an old technology with large scale commercial application. Cryopreservation of embryo is an advanced technology that has achieved considerable success with birth of calves after transfer of cryopreserved embryos (Kandil et al., 2014). Cryopreservation of oocytes and somatic cells has practical application for cloning and gene banking. Even though sperm, embryo, and somatic cell cryopreservation succeeded and these are now routine activities, oocyte cryopreservation remains a challenge.

Recent studies (Tasripoo et al., 2014) showed improvement on development to morulae and blastocysts after NF of oocytes cryopreserved by slow-freezing and verification but the efficiency remains lower than that for fresh oocytes (Hufana et al., 2008). Efficiency of oocyte cryopreservation requires further refinement before it can beused for routine application. The high lipid content of buffalo oocytes may influence the success of cryopreservation (Zhang et al., 2011).

Sperm sexing

Sperm sexing provides the opportunity to produce offsprings of pre -determined sex. This was made possible by the creation and development of low cytometer. Proof of sorting efficacy has been demonstrated in many species and numerous applications in a variety of species is anticipated including endangered species and zoo and aquarium animals. In water buffaloes, successful results on sperm sexing were also achieved (Tasripoo et al., 2014). Accuracy of sexing is around 90% in most species. However, this technology is still rather expensive due to the low sexing efficiency where only about 20 million sperm cells are sorted in an hour which is the concentration required for cryopreservation.

For ET, embryo straws are recovered from liquid nitrogen tank and the pointed dose for artificial insemination in water buffalo. Furthermore, fertility of sexed sperm is lower than unsexed controls (Kandil et al., 2014) leaving room for improvement. Advances have been made in two main areas: increasing the number of sperm sexed accurately per unit time, and making the process less damaging to the sperm by optimizing the pressure in the flow cytometer (Zhang et al., 2011). The possibility of choosing a male or female calf can be done by the use of X and Y - sorted sperm in artificial insemination or *in vitro* fertilization programs. Studies and application in the United States in the year 2005 had significant positive impact on dairy cattle and beef cattle production systems by producing the desired sex and nearly doubling the productivity. In water buffaloes, calves of sex pre-determined were born (Hufana et al., 2008).

The same authors found DNA contents between their X- and Y-chromosome-bearing spermatozoa; a difference large enough to allow successful sorting. Although the numbers of sorted spermatozoa per hour have currently attained larger figures than those from a decade ago (50-100 million compared to 350,000), these numbers imply fewer sperm doses for AI, reducing their application for conventional breeding. The technology is, however, very promising and provides opportunities for sex selection of IVEP-embryos (Tasripoo et al., 2014*)*, surprising the need for sex diagnosis of the embryos (which is reliably done today by DNA probing, specific for the Y chromosome, but still time-consuming and perhaps not risk-free) (Jain et al., 2011).

Sex-sorting, albeit interesting for animal breeding strategies, is too costly (a flow sorter costs above $300,000 US), slow, and yields weak spermatozoa with a reduced lifespan. Nevertheless, sexed semen is commercially available (male- or female- sorted spermatozoa) and it is becoming more competitive in cattle (Tasripoo et al., 2014*)*. In buffaloes, deposition of sexed semen in the body of the uterus yielded higher pregnancy rates (45.5%) compared to when sexed semen was deposited in the uterine horn (32.3%).

Conception rates did not differ between adult buffaloes and buffalo heifers; however there was a difference between bulls (Tasripoo et al., 2014). Most studies in buffaloes have reported the use of sexed semen fur insemination after an estrus synchronization protocol (Zhang et al., 2011). A recent study, however, evaluated the insemination of 4521 swamp or crossbred buffaloes during natural estrus with X-sorted semen from river buffaloes and recorded a 48.5% pregnancy rate and 87.6% sex accuracy (Yang and Pang, 2010). A similar previous study on Chinese swamp buffaloes (n=3863) that were inseminated with X-sorted river buffalo semen during natural estrus, recorded calving rates of 51.9% and sex accuracy of 89.0% (Kandil et al., 2014). These studies reflect the prospects of commercial application of insemination with sexed semen in the buffalo.

Cloning

Somatic cell nuclear transfer (SCNT)

In SCNT, the nucleus of the somatic cell is transferred to an enucleated recipient cytoplast which is then stimulated to divide and develop into an embryo. This technology in the livestock industry is huge but the efficiency of implementation in water buffalo is slow and challenging. Successful cloning in water buffalo was shown through the production of cloned calves reported by the use of fetal fibroblasts or granulosa cells as donor cells (Jain et al., 2011), ear fibroblast nucleus from river buffalo in hand-made zona-free cloned vitrified embryos derived from enucleated oocytes reconstructed using adult skin fibroblast cells as nucleus donor. Cloning can be done using a micro manipulator-based cloning procedure (Zhang et al., 2011) or by hand-made procedure.

On the use and efficiency of donor cell type (Saba et al., 2013) fusion, activation and culture systems (Tasripoo et al., 2014) have been explored with varying success. Cloned embryos produced from nucleus transfer of buffalo fetal and adult somatic nuclei into enucleated bovine oocytes and subsequent development to the blastocyst stage has been reported (Kandil et al., 2014). Most previous studies have utilized adult or fetal fibroblasts as nucleus donors (Misra and Tyagi, 2007) however, some of the more recent reports depict the successful production of cloned embryos by nucleus transfer from cells other than fibroblasts such as somatic cells isolated from urine (Jain et al., 2011) amniotic fluid derived stem cells (Purohit et al., 2003*)* and somatic cells from milk (Zhang et al., 2011).

Cloned embryos have also been produced by nucleus transfer of somatic cells (fibroblasts from ear) from wild buffalo and oocytes from domestic buffaloes (Saba et al., 2013) and live births resulted following SCNT from river buffalo somatic cells and swamp buffalo oocytes (Yang and Pang, 2010). Hand-made cloning has proved to be an efficient alternative to the conventional micro-manipulator-based technique (Shi et al., 2007). Research *in vitro* cleaved medium was reported to be an effective culture system compared to medium for *in vitro* culture of zona-free cloned buffalo embryos reconstructed using adult skin fibroblast cells as nucleus donors (Tasripoo et al., 2014*)*; factors are generally employed as recipient cytoplasts for SCNT(Lu et al., 2007). GO stage of the cell cycle to avoid chromosomal damage and abnormal in the resulting embryos (Tasripoo et al., 2014). Serum sperm sexing offers an obvious advantage buffalo is limited, the techniques have been commercialized dairy buffaloes present about 3.8% differences very embryos embryo's natural embryo.

Embryo splitting

In embryo splitting, before reaching the differentiation stage, an embryo is split in to 2, 3 or 4 depending on the efficiency of splitting. The separated blastomer's are further cultured for development to preimplantation stage. The resultant embryos are clones. The clone carries exactly the same DNA of the original embryo that was split. Embryo splitting is a technology that allows the development of several embryos from a single embryo. It is a cloning method where a healthy embryo is divided by taking some blastomers and implanted into an empty zona pellucida to develop another embryo. It involves splitting or dissecting of young embryos into several sections (Liang et al., 2008), usually at the 2 to 8 cell stage, although some reports used morula-stage embryos before the cells differentiated.

The sections are further cultured to develop into a new embryo that upon reaching the pre implantation stage can be cryopreserved or transferred to recipient animals. The procedure requires specific microscopy and micromanipulations to carry out the extremely delicate micro-dissection needed when world with the embryo. A pregnancy rate of 120% was reported by this technique because by dissection, a 50 to 60% success rate after transfer of each half embryo was achieved when transfers were done using the same receptor female (Hufana et al., 2008).

Animal biotechnological options for Asian countries

A number of specific options can be identified that should assist Asian developing countries make informed decisions regarding the adoption of appropriate biotechnologies in the livestock sector in the future.

Biotechnologies should build upon existing conventional technologies

Solving new problems will require novel ideas and may involve new technologies. However, substantial impact of new biotechnologies can only be realized at the ground level in developing countries if the capabilities and infrastructure to effectively use conventional technologies are in place. For example, molecular diagnostics and recombinant vaccines will not improve the health or well-being of animals if an effective animal health infrastructure does not exist. Semen sexing and ET have no relevance in places where less advanced reproductive technologies such as AI are not well established and systems for the distribution of improved germplasm are not in place (FAO, 2011). Efficient animal identification systems, for example based on ear tags, animal passports and computer recording, are needed in order to take full advantage of molecular markers, DNA sequencing and other advanced biotechnologies for animal genetics, nutrition and health (Shelke et al., 2011).

Biotechnologies should be integrated with other relevant components in any livestock development programmes

Not all biotechnologies can be applied successfully in all situations at all times. Each biotechnology has relevance to a specific situation and in most cases; it has to complement conventional technologies and other components of the livestock production and marketing system to elicit the desired impact for the farmer. An example is the integrated programme involving farmer organizations, extension workers, researchers and policymakers that reversed the decline of a locally adapted dairy sheep breed in Tunisia (Djemali et al., 2009). The increasing importance of environmental issues also means that these should also be considered in any livestock development programme. For example, plans for the application of biotechnologies for nutrition (for example prebiotics and probiotics, enzymes and silage additives) should consider both the effects on animal productivity and the potential impacts (positive or negative) of the technology on the production system and the environment (FAO, 2011).

Application of biotechnologies should be supported within the framework of a national livestockdevelopment programme

Developing countries must ensure that animal biotechnologies are deployed within the framework of national development programmes for the benefit of producers and consumers and not as stand-alone programmes. The models of biotechnology interventions in developing countries differ distinctly from those in developed countries (Zhang et al., 2011). The biotechnologies that are simple and cost-effective are more likely to be successful in developing countries. To ensure the successful application of a biotechnology in the complex and diverse animal agriculture scenarios present in developing countries, not only does the mitigation of technical challenges need to be addressed but also, and probably more importantly, issues like management, logistics, technology transfer, human capacity, regulation and intellectual property (FAO, 2011). Policy-makers in developing countries should be aware that there would be practical, financial and legal obstacles that will preclude the full-scale adoption of many livestock biotechnologies (Saba et al., 2013). Therefore, strong scientific drive, vision and entrepreneurial skills are needed to contribute to progress in animal biotechnologies in developing countries.

Access to biotechnological products by end users should be ensured

An appropriate model for scaling up and packaging the technology should be integrated into the development and application of biotechnologies and biotechnological products, particularly for vaccines, diagnostics, probiotics, prebiotics and enzymes so that the products are not cost-prohibitive. It has to be borne in mind that the target end users of these biotechnologies in developing countries are normally resource-poor farmers with limited purchasing power. Without this scaled-up business approach/model, even good science and quality biotechnological products might not deliver desired impacts at the field level (FAO, 2011). In the business model, it is also imperative to consider the intellectual property issues, which impinge on several aspects of biotechnology. For example, for manufacturing a recombinant vaccine, developing countries might find that theuse of antigens, delivery mechanisms, adjuvants and the process are already patented and subject to intellectual property conditions (Kandil et al., 2014).

CONCLUSION

One of the methods that are believed to accelerate maintaining the livestock production is the use and application of reproductive biotechnology in a wide range of and/or intensively to the producers. Agricultural biotechnology has the solution to the problem of global food insecurity. Agricultural biotechnology has the potential to address some of the problems of developing countries like food insecurity, unfavorable environmental and climatic conditions, etc mentioned above and also improve agricultural productivity.

The Asia reproductive Biotechnology Society was established in 2004 to promote the educational and scientific interests of the reproductive biotechnology research community throughout Asia. The society includes active scientists and students working in many Asian countries, including Japan, South Korea, China, Vietnam, Thailand, Indonesia, Malaysia, India, Singapore, Bangladesh, Taiwan, Laos and Cambodia, Iran, Mongolia, Brunei, United Arab Emirates (UAE), etc. and serves as the region's premiere forum for scientific discussion and exchange in this field. The main objectives of using reproductive biotechnologies in livestock are to increase production, reproductive efficiency and rates of genetic improvement. Over the years, many options have become available for managing the reproduction of the major large and small ruminants. In recent times, reproductive biotechnologies have emerged and started to replace the conventional techniques. These recent bio-techniques, both in male and female, have revolutionized and opened avenues for studying and manipulating the reproductive process both *in vitro* and *in vivo* in various livestock species for improving its efficiency.

Generally, in most of South East Asian Countries (Combodia, Lao) the reproductive biotechnologies such as synchronization embryo transfer and cloning have never existed and do not have national policy. Currently in most developed Asian Countries like Japan, reproductive biotechnologies both in male and females animals are widely developed; like embryo cryopreservation, embryo transfer, embryo splitting, cloning etc while in other developing Asia countries like Combodia and Lao it is still in the developing stage.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Assesment of quality and marketing of hide and skin in Adamitulu Jidokombolcha and Bora Woreda in East Shewa Zone of Oromia Regional State, Ethiopia

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Hide and Skins are important economic products contributing to the largest share of the total and agricultural export commodities followed by live animals in Ethiopia. The current study was conducted with the objective of assessing the major causes of hide and skin defect, quality, and marketing of the raw materials in Adami-Tulu and Bora district. A total of 768 (382 sheep and 220 goat skins and 76 cattle hides) sample was randomly selected and visually examined for defects at the collection centers. Further, 20 apparently health and 20 apparently defective goat skins were selected randomly and tested for physicochemical characteristics including tensile strength/mm², elongation percentage, tear load, thickens (mm), fat content and moisture content at crust stage of processing. A questionnaire survey was also done with 200 respondents to assess the marketing situation of hide and skins in the study areas. Major defects before processing were cockle (36.6%), flay defect (51.6%), scratch (60.7%), scar (26.2%) and putrefaction (17.5%), and brand (0.5%). The proportions of scratch, flay defect and cockle were higher in goat skin, sheep skin and cattle hide, respectively (P<0.05). Both defective and apparently normal goat skins after tanning to wet blue stage have demonstrated different types of defects. Prevalence of cockle, scratch, putrefaction and pox lesion was increased after processing defective skins. None of the skins considered normal were free of defects. However, the appearance of defects such as cockle, scratch, putrefaction and pox lesion was higher in defective than in those considered normal (P<0.05). Grading at wet blue stage revealed that majority of skins in both groups earned grades 3 to 5; there was no grade one. On the other hand, physico-chemical examination (tensile strength, percentage elongation, tear load, moisture, content, etc.) as a reflection of the natural characteristics of goat skin showed that both groups classified defective and normal, had within standard or better performance as compared to the Ethiopian Standard set by the authority. It can be concluded that if the major defects are significantly reduced, access to market and market information is improved. Raw hides and skins in the study areas as reflected from goat skin analysis have outstanding natural characteristics that could make them qualify for better grades in the market.

Key words: Adami-Tulu, Bora, defects, hide and skins, marketing, physico-chemical characteristics.

INTRODUCTION

In Ethiopia, Agricultural development is considered a priority by the government for stimulating overall economic growth, reducing poverty and achieving food security. The agricultural sector of Ethiopia accounts for about 42% of gross deomestic product (GDP), more than 80% of export, and 85% of employment. The livestock sector contributes 45% of agricultural GDP and 16 to 19% of the foreign exchange earnings of the country

(Behnke and Metaferia, 2011). Furthermore, the country's foreign exchange from livestock product is increasing, with spiking trend for leather and meat products (MOA, 2009). Skins and hides are the most valuable export item for the country other than coffee. The leather industry is one of the fastest-growing economic sectors in Ethiopia (Abadi, 2000; Bayou, 2007).

Despite the availability of these physical resources, the leather sector contributes only marginally to the national economy so far. This could be mainly due to the presence of livestock disease and difficulties to meet international standards (CSA, 2011). Skin and hide quality is usually assessed by international standards of physico-chemical tests, which are intended to guarantee leather quality and uniformity (Tsegay et al., 2012). Hide and skins are known to have varying physical and chemical properties and thus used for different purposes. Commodity trade patterns have changed during recent years and practical methods for evaluation and classification of skin are necessary (FAO, 2010).

The current utilization of hides and skins in Ethiopia is estimated to be 48% for cattle, 75% for goat and 97% for sheep with expected off take rate of 33, 35 and 7% for sheep, goats and cattle, respectively (Mahmud, 2002). Basic information on the quality level is useful to decide for what purpose to use the hide or skin. However, such quality information is meager in Ethiopia. This calls for detailed information on the internationally required physical and chemical properties of hides and skins to identify potential market and earn from the attractive international leather market. Thus, this study aims to assess the quality and marketing of hide and skins in Adami Tulu and Bora district of Oromia Region through pre and post slaughter defect assessment and physico-chemical analysis.

MATERIALS AND METHODS

Study area description

This study was conducted in Adami Tulu and Bora districts. Adami Tulu district is found in east Shewa zone of Oromia Region at about 168 km south of Addis Ababa, which is located in the central rift valley of Ethiopia with an elevation of 1636 m.a.s.l. The district is characterized by mixed livestock farming system. Cattle, goat, sheep and donkey are important livestock species reared in the area (ATJK District Livestock Development and Health, 2008). Bora district is also found in East Shewa zone of Oromia Region of Ethiopia. Hides and skins are important commodity in both study area. Sheep and goat skin comprises more than 85% of the marketed skin in the districts.

Study design

A cross-sectional study design was employed to study the hide and skin market, defect and quality at the level of producers (homestead slaughter), middlemen, butchers and hide and skin collection centers. The two districts were Adami Tulu and Bora selected purposively based on hide and skin supply and accessibility. Two stage random sampling procedure was applied to select representative farmer household. For the homestead hide and skin suppliers, five peasant districts from each district were selected randomly from the list provided by district offices. The lists of households from each selected district were obtained from development agents. Systematic random sampling procedure was employed to obtain names of households to be interviewed.

Sample size determination for questionnaire survey

The sampling units were homestead hide and skin suppliers in the study area. The sample size required for the study was determined to be 200 respondents by the formula recommended by Arsham (2007) for survey studies. In addition to this, all hide and skin collection centers were also interviewed; the number of middlemen, butchers and tannery were unknown; those encountered during the study were included.

Sample size determination for hide and skin defect prevalence at the collection centers

There is no previous investigation or assessment about the defect of hide and skin in the study area. Hence, the average expected prevalence rate was assumed to be 50% for the area within 95% Confidence Intervals (CI) at ±5% desired accuracy. Subsequently, the number of study hide and skin was determined from the formula published in Thrusfield (2005). Using the aforementioned formula; the sample size is calculated to be 384 irrespective of the animal species (sheep, goats and cattle) per district. However, to increase the power of the study, 382 goat skins were sampled for physical defect assessment. Furthermore, 20 apparently healthy and 20 skins with generalized pre-slaughter defects were purposively selected, preserved and these materials have been sent to Leather Industry Development Institute, Addis Ababa, Ethiopia, for laboratory tests using the SANAS test methods (South Africa National Accreditations Standards). The test result of tensile strength, percentage elongation and tear load, thickness, moisture content on dry basis and fat content has been collected and then manipulated using descriptive statics.

Data collection

Questionnaire survey

The questionnaire was pre-tested and then modified on the basis of the information obtained in the pre-tests. Totally, 200 homesteads hide and skin suppliers were involved; they were interviewed on household herd composition and animal slaughter rate.

Observation

The market condition was observed in the collection center wholesalers focused on the price determination of raw hide and skin. The observation was also utilized to assess the status of hides

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and skins defect. For this purpose, a systematic random sampling technique was employed where every other hide/skin was considered to assess hid and skin defects at the collection centers.

Physical and chemical examinations

For physical defect assessment, at the collection centers, randomly selected 382 goat, 220 sheep skin and 76 cattle for defects such as cockle, scratch, fly cut, pox, brand, scar and putrefaction were searched for and examined using protocol described on parasitology text book. Furthermore, 40 raw goat skin was selected randomly and classified into generalized defect (grade two and three) and apparently normal (with grade four and five) to test physico-chemical characteristics like skin by appearance/defect, tensile strength, percentage elongation, tear load, thickness, fat content and moisture content. The skin was preserved by wet salted and kept in the collection center for one month. Then, the preserved skin was transported to Addis Ababa Leather Industry Development Institute for further analysis of physico-chemical test skin quality. The skin samples taken from the defected and normal goat skins were tested for physical characteristics like, tensile strength and percentage elongation were determined using test method of International Organization for Standardization (ISO-3376, 2002). Average tear load mean was determined using test method of International Organization for Standardization (ISO-3377, 2002) and sampling method and sampling location for these characteristics were according to ISO-2418 (2005). Thickness was in accordance with ISO-2589 (2002). In the other hand, chemical testing like moisture and fat content were determined according to SLC4 (1996) test method.

Procedure for skin laboratory test

First goat skin was pre-soaked by using 200 L water for 5 min and washed three times followed by the soaking process using 150 L water, 0.2 kg sodium silico fluoride and 0.3 kg soda ash; then it was left overnight (~16 h) to run for every 2 h, drain next morning, press and pile for 4 h, checked (pH 9-9.5) → Painting which was used for hair shaving by using 100 L water with 1 kg sodium sulfate for about 30 min. The fourth process→ Liming by using 100 L water, 1 kg sodium sulfate and 1 kg sodium sulfhydrate for 30 min and leave overnight and 3 times stop at 27 min, then → Deliming process using 250 L water, 1 kg ammonium sulfate and 0.5 kg sodium bicarbonate for 45 min and check (pH 8-9) followed →Bating process using 100 L water and 0.5 kg bating enzyme for 30 min and drain and wash.

Then, → Degreasing using 80 L water for 20 min then drains and wash. The next was pickling using 80 L brine (water+salt) for 10 min, 1 kg formic acid for 20 min and 0.8 kg sulfuric acid for 30 min and dilution check Be° (2.8-3) → Tanning using 3 kg basic chromium sulfate, 1 kg sodium formite and 0.8 kg sodium bicarbonate for 30 min and check (pH 3.6-3.8). Within this process at wet blue stage defect assessment, grading was done. Then → Acid wash using 200 L water, 0.3 kg formic acid and 0.2 kg non-ionic detergent agent were left for 1 h and then checks wet back drain→ neutralization using 100 L water and 0.1 kg sodium formite, then was left for 30 min check (pH 4.2-5) and drain→ Re tanning using 150 L water, 4 kg retinal LSF, 3 kg genetan Lx, mimosa and 2 kg net fill powder then left for 60 min drop by drop. → Fat liquoring using 50 L water, 3 gene soft Fc 3 gene soft Sc, 2 nexopolnt and Fosfol 36-k after that check (pH 3.5-3.6) and drain→ Fixation using 2 kg formic acid left for 45 min after that drain, wash, pile, hanging up, hanging dry, conditioning, milling and toggling.

Data management and statistical analysis

Data on hide and skin quality including visual defect observation and physico-chemical test results were stored in Microsoft excel spread sheet and transferred to SPSS version 20.0 for analysis. Market condition and associated constraints of hide and skins was determined by using frequency distribution. Similarly, the occurrence of defects and grading of skin at wet blue stage also was determined by using frequency distribution. On the other hand, independent sample T test was performed using SPSS version 20.0 to compare the mean of physico-chemical characteristics of crust goat skin with the standard. P value ≤0.05, was considered statically significant.

RESULTS

Characteristics of hide and skin producers and marketers

The characteristics of the household respondents are described in Table 1. The average household male respondents were 77% and the mean numbers of females were 23%. About 54% of the house hold respondents were found in age group between 25 and 44 years, 43% of the households were between 45 and 64 years and the remaining 3% of the house hold respondents were above 65 years old. In the study area, moreover, 50% respondents were illiterate, 24% only read and write, 18% completed primary school, 6% joined secondary school and 2% had diploma. On the other hand, all butchers (20) available for interview were males in the study area. In general 45% of butchers were in the age group between 25 and 44 years and the remaining 55% butchers were in the age group between 45 and 64 years old. All the ten middlemen encountered were males of which 50% were in the age group between 25 and 44 years and the remaining 40% in the age group between 45 and 64 years old and 10% had above 64 years of age. On the other hand, all collection centers (2) or traders available for the study were males and all respondents were of the age group between 45 and 64 years old in the study area.

Livestock herd composition and annual slaughter at household

All interviewed household respondents keep mixed species livestock farming system where cattle, sheep and goats are the widely prevalent species in both study district (Table 2). In the study area, for all the three species, the mean annual slaughter at the household level ranges between two and three animals (Table 3).

Household respondents ascertained that majority of them use hides and skins for cash income whereas significant number of them keep raw materials for making household utensils (Table 4).

Table 1. Characteristics of hide and skin producers and marketers.

Variable	Market agents			
	Farmers (N=200)	Butchers (N=20)	Middlemen (N=10)	Trader (N=2)
Sex				
Male (%)	77	100	100	100
Female (%)	23	0	0	0
Age				
15-44 (%)	54	45	50	0
45-64 (%)	43	55	40	100
>65 (%)	3	0	10	0
Education level				
Illiterate	50	35	50	0
Read and Write (%)	24	25	30	0
Primary school (%)	18	15	20	50
Secondary school (%)	6	15	0	50
Diploma (%)	2	10	0	0
Total	100	100	100	100

Table 2. Overall herd distribution.

Species composition (N=200)	Percentage
Cattle, sheep, goat, donkey and horse	14
Cattle and goat	12
Cattle and sheep	14
Cattle, sheep and goat	31
Cattle, goat, sheep and donkey	13
Goat and sheep	7
Cattle, sheep and donkey	9
Total	100

Table 3. Mean number of sheep and goat slaughtered at household level.

Type of animal slaughter (N=200)	House hold level (Mean ± SE)
Goat slaughter	2.94±0.092
Sheep slaughter	2.75±0.105
Cattle slaughter	2.55±0.080

Defects of skin and hide observed at collection centers

Defects identified on goat skin after processing

Visual examination of 768 of raw cattle hides and skins of goat and sheep revealed at least two defects in 97.8% of them. As a result, the common defects attributed to quality deterioration were cockle, flay defect, scratch and scar, putrefaction, brand and pox (Table 5). Example of flay cut, scratch and putrefaction is as shown in Figures 1, 2 and 3, respectively.

Both defective and apparently normal goat skins after tanning to wet blue stage have shown different types of defects. Prevalence of cockle, scratch, putrefaction and pox lesion was increased after processing defective skins. None of the skins considered normal were free of defects. However, the appearance of defects such as

Table 4. Use of hide and skin for sampled house hold farmers.

Use of hide and skin	Percentage
Cash income	73.5
Make utensils	12.0
Cash income and make utensils	14
Not so important	0.5
Total	100

Table 5. Hide and skin major defects.

Major defects (%)	Goat	Sheep	Cattle
Cockle	36.6	54.5	68.1
Flay defect	51.6	55.9	50
Scratch	60.7	29.5	29.5
Scar	26.2	21.8	19.3
Putrefaction	17.5	30	18.7
Pox	2.4	0	0.6
Brand	0.5	0	9.6
Total examined	382	220	76

Figure 1. Goat skin with flay defect.

Figure 2. Goat skin with scratch.

cockle, scratch, putrefaction and pox lesion was higher in defective than in those considered normal (P, 0.05) (Table 6).

Grades given to goat skin grouped as defective and normal

Goat skin grading done at wet blue stage revealed that

Figure 3. Goat skin with putrefaction.

Table 6. Defects recorded after processing goat skins identified defective and normal.

Point of defect assessment	Defect type											
	Cockle (%)		Flay cut (%)		Scratch (%)		Scar (%)		Putrefaction (%)		Pox (%)	
	D	N	D	N	D	N	D	N	D	N	D	N
Before processing	45	0	45	0	25	0	45	0	35	0	10	0
After processing	80	30	20	50	60	30	30	70	70	20	20	10

Hint D: Defected skin; N: normal skin.

Table 7. Skin grading at wet blue stage.

Group	Grade level at wet blue stage				
	2	3	4	5	6
Defective	5	25	25	30	15
Apparently normal	5.3	10.5	26.3	47.4	10.5

most skins lie in the category of grades three to six for defective skins, whereas most skins previously considered normal fall in grades four and five. More rejected skins were found in the group labeled defective. Details are shown in Table 7.

Physico-chemical characteristics of goat skin

In the laboratory, physical quality analysis of goat skin labeled defective and normal in their fresh state was done at crust stage of processing. The findings revealed

Table 8. Physical analysis and chemical testing defected crust goat skin in the study area.

Parameter	Tensile strength (mm²)	Elongation (%)	Average tear load (N)	Tear load (N/mm)	Thickens (mm)	Fat content	Moisture content
Mean ± SE for defective	26.24±0.66	51.1±1	48.8±1.56	52.72±1.81	0.93±0.3	6.6±0.2	10.8±0.11
Mean ± SE for normal	27.24±1.15	52.2±0.71	54.2±2.17	55.93±1.27	0.97±0.03	6.55±0.33	10.83±0.1
Standard value	≥15	40-70	50	100-125	0.7	3%	14-18

Table 9. Market flow of hides and skin.

Producers/Traders	Middlemen (%)	Local processor (%)	Collection center (%)	Tannery (%)
Farmer (N=200)	54	1.5	44.5	0
Butcher (N=20)	25	0	75	0
Middlemen (N=10)	0	10	90	0
Collection center (N=2)	0	0	0	100

Table 10. Selling price of hides and skins to different market actors.

Product	Market actors and price in birr (ETB)			
	Producer to middlemen	Middlemen to collection center	Producer to collection center	Collection center to tannery
Sheep skin	32±0.24	38.1±0.3	38.1±0.3	65
Goatskin	7±0.24	13.1±0.26	13.1±0.26	26
Cattle hide/kg	2.9±0.05	4.23±0.1	4.23±0.1	10

that both groups of skins had higher tensile strength and thickness than the standard. On the other hand, elongation capacity was within the standard range for both. On the contrary, the moisture content was lower than the standard range whereas the undesirable fat content was higher than the maximum preferred in both cases. When values between defective and normal skins were compared and there was no significant variation for most of the measurements except a borderline significance for average tear load in Newton (P=0.051), and it is higher in skins considered normal than those taken as defective (Table 8).

Hide and skin marketing

Market flow and selling price

Majority of farmers sell their raw hide and skins to middlemen followed by collection centers. On the other hand, most butchers and middlemen sell their raw materials to collection centers (Table 9). Selling price increases as it goes from producers to tannery (Table 10). Producers earn better price when they sell hide and skins to collection centers than when they sell them to middlemen.

Factors affecting marketing of hides and skin

The survey result revealed that hides and skins market price was commonly determined by the buyer followed by negotiation based on quality of the product (Table 11).

Access to market information is one of the determining factors in hide and skin marketing. Results from the survey also showed that majority of the hide and skin producers do not get proper information on the price of the products prior to selling (Table 12).

Skin diseases and lack of competitive market were also among the major problems hampering hide and skin marketing. Other constrains were flay defects and injury as well as fluctuating prices (Table 13).

DISCUSSION

In the modern era, high quality commodities including leather products require practical methods for evaluation and classification (FAO, 2010). This study was initiated to assess the quality and marketing of hide and skin in two

Table 11. Hide and skin price determinant.

Actors/Agents	Price determinant		
	Seller themselves (%)	Buyer (%)	Negotiation (%)
Farmer (N=200)	13.0	79.5	7.5
Butcher (N=20)	0	65	35
Middle men (N=10)	30	20	50.0
Traders/collection center (N=2)	0	70	30.0
Total (%)	100	100	100

Table 12. Hide and skin production and market constraint.

Production problem (N=200)	Respondents (%)
Disease	**48.5**
Flay defect	32
Injury	19.5
Market problem (N=200)	
Lack of competitive market	53
Fluctuating price	29
Lack of price information	18
Total	100

Table 13. Market information source for hides and skins producers and marketers.

Information source (%)	Market actors			
	Farmers (N=200)	Butchers (N=20)	Middlemen (N=10)	Traders (N=2)
Personal observations	12	20	60	20
Broker	5	15	0	0
Friends or other producers	17	15	40	50
No information	66	50	0	0
Mass media	0	0	0	30
Total	100	100	100	100

selected district of East Showa Zone of the Oromia National Regional State. According to our survey response, majority of the hide and skin producers sell their raw materials to the market to generate income. Similarly Hadush et al. (2013) in Tigray region and Asegede et al. (2015) reported that only 31 and 44.14%, respectively of household respondents sell skin to formal market. There were also a number of respondents' who ascertained that they use especially cattle hide for making household utensils. Hadush et al. (2013), Koloka and Moreki (2010) and Kagunyu et al. (2011) have also reported that hide and skins are used as a source of various materials for household use. This suggests that, although majority are aware of the importance of bringing hides and skins to the market, there are still significant number of the raw materials that fail to be channeled to the collection centers and tanneries.

Several reasons may contribute to low quality output. According to Jabbar and Benin (2002), poor animal husbandry (including inadequate and poor quality feeds, inadequate parasite and disease management) and inappropriate slaughtering, flaying, collection and initial processing methods used. Through visual inspection at collection centers in the study area, the most common Hide and skin defect were defects cockle, flay defect, scratch, scar and putrefaction. Similarly, Jabbar and Benin (2002) reported that poor animal husbandry (including disease management) and inappropriate slaughtering, flaying, storage downgrade quality of skin and hide. Nationally, poor pattern, dirt and knife cut were reported as the main defects of sheep and goat skin (CSA, 2004). Berhe (2009) in Tigray also reported that diseases and fly cut were the main defects of the hide and skin. On the contrary, Bezabih (2014) has shown that filthiness, gauge marks and flay cut or poor pattern are the most important defects of sheep and goat skin and cattle hide in East Gojam Zone of the Amhara Regional State. In a similar way, our findings disagree with the report of Kiruthu et al. (2000) that poor pattern, dirt and corduroying were the chief defects of wet sheep and goat skin in Bahrdar town. This suggests that differences in the perception and practices of hide and skin management by the producers in different regions of the country. However, comparative to other studies and species, high proportions of scratches in goat skins were reported. This could be because of the browser feeding behavior of goats, such that they are vulnerable to spine abrasions, thorny bushes on grazing and the thin layer of hair coat that cannot protect the skin from injury during rubbing against an object. As a result, goats are more likely to acquire scratches on their life-spans than of sheep. Cockle was also the major defect observed in all the three species. This is in line with the report of Kassa (2006) that cockle, mange mite and pox are the main treats to the leather industry in Ethiopia. The defect assessment undergone at wet blue stage of processing magnified some of the defects suggesting that visual inspection is inefficient to detect all the defective skins. Also, those skins considered free of defects in the fresh/wet state were found having one or more defects. At this stage most defects are easily visible as the hairs are removed. Similarly, the appearance of defects such as cockle, scratch, putrefaction and pox lesion was higher in skins designated defective than in those considered normal in a fresh state indicative of the relative importance of visual inspection. It was shown that majority of goat skins identified as defective in a fresh state were categorized under grades 3 to 5, whereas most of the skins considered normal were grouped under grades 4 to 5 supporting the fact that apparently health skin does not always mean that they earn a better grade. Animals with skin diseases previously treated may remain with a permanent damage which is not visible with the necked eye. Producers may attempt to hide flay defects of various types by covering them with flesh, etc., so that such defects may be missed during inspection. An example to support this assumption is the detection of fly cuts in 50% of those skins labeled normal before processing. It could also be attributed to the experience of the inspector to identify and detect the different types of defects. Goat skin grades reported by Bezabih (2014) significantly varied from our report. He indicated that about 85% of the skins fall in grades 1 and 2. This variation could be the result of the grading technique. Grading in the present study was at wet blue stage of tanning, whereas Bezabih graded the skins at wet salted stage before processing. The present finding is in line with the conclusion that large amount of money is lost due to direct rejection or costs incurred for defective skin processing (Sertse and Wossene, 2007).

The tensile strength of both defective and the apparently normal goat skin in the present study was higher than the minimum value recommended by standards. Salehi et al. (2014) in goats from sub humid hilly areas of Iran have also demonstrated that goat skin had tensile strength of 26 N/mm^2 which is equivalent to the present finding. Similarly, percentage elongations of both defective and normal skin in the present study were higher than the minimum value recommended by standards. This high performance in percentage elongation emphasized that the skin has enough elasticity that provides good adaptation to users' size to the movements derived from the use of footwear. Percentage elongation in this study was lower than the value (56%) reported by Salehi et al. (2014) which indicates existence of breed difference in the elongation capacity of goat skin. The current result shows that both defective and normal skin tear load was below the minimum requirement recommended by Ethiopian standards. It is also lower than values reported by some other researchers such as Salehi et al. (2014) in Iran who reported tear load of around 23.5 N/mm. The thickness of the present study in both defective and normal skin was above the minimum. This result demonstrates that skin had better quality which makes it more suitable for making boots and garments. The present result was similar to Salehi et al. (2014) in their measurement of physical properties of Iranian Lori goat breeds. Similarly, other finding supported the present study (Oliveira et al., 2007) that goat leathers are thicker than leathers obtained from sheep. On the other hand, the chemical test indicated moisture content of both defective and normal skin was lower than the minimum value recommended suggesting again the good natural quality of the products. This result was similar with Sudha et al. (2009), Salehi et al. (2014) and Passman and Sumner (1983) and their estimation for moisture content was around 11% on crust tanned sheep leather. Different from the aforementioned fact, the fat content of our goat skins was higher than the maximum recommended, probably due to the fact that most goats are slaughtered at old age where the probability of fat deposition is high. Similar findings (5.8%) were also reported for goats in Sudan (Musa and Gasmelseed, 2013). The present result indicated that most household producers sell skin or hide in the form of fresh to middlemen (brokers). Even though brokers have not license they are easily accessible to household producers and collect directly going door to door in case of urban area and by setting temporary collection point at most accessible spot in case of rural areas. This finding is line with Hadush et al. (2013) who reported that 21% of respondents sell hide and skin to middlemen. However, selling to middlemen than collection centers makes them lose better price offer since collection centers buy the products at the same price from both middlemen and household producers. In the study area, marketing flow of hide and skin starts from producers (farmers, butchers) and agents could be middlemen and collection centers with final destination to tanners, this is in agreement with Ahmed (2000) who reported that the market chain for raw hide and skin consists of the primary producers/consumers, who were the initial sources (individual meat consumers, rural slaughter slabs, municipal slaughter houses, abattoirs, meat processing plants), agents of traders, collectors, local tanners, regional medium/small traders, regional/ Addis Ababa big traders and tanneries. In the study area producers (farmers, butchers), the average selling price of sheepskin, goat skin, and cattle hide was 32±0.24 birr/pieces, 7±0.24 birr/pieces, 3±0.48 birr/kg, respectively to middlemen. Price offer increases as it goes from producers to tannery. However, it should also be noted that costs of storage, preservation and transportation would increase the cost of supply especially at collection centers and tanneries. The average price of the current finding disagree with the finding of Hadush et al. (2013) who reported that the average selling price of raw sheepskins was 41.43 birr. In the study area, there was lack of real price setting available for producers, even though the price of hides and skins was a reflection of world market price and the behavior of traders in pricing, an attempt was made to examine discriminating or competitive pricing strategy for hide and skin traders. For most of the household hide and skin producers, price is determined (set) by buyers. Similarly, traders have the leading role to determine skin and hide price at butchers' level. The present finding is similar with Berhe (2009) who reported that hides and skins prices were determined by buyers in 62.8% of the cases. Scarborough and Kydd (1992) said that accurate and timely market information enhances market performance by improving the knowledge of buyers and sellers concerning prices, production, supply movements, stocks, and demand conditions at each level of the market. Market access and lack of price information as well as absence of competitive market are among the major constraints in hide and skin marketing in our study areas. The current finding is similar with ILCA (1990) and who stated that absence of market information system minimizes the share of the total value that producers receive. Tschirley et al. (1995) stated that the existence of information barriers results in unexploited market opportunities, seasonal gluts and produces inadequate quality specification and control, inequitable returns to producers and fundamentally poor returns to production and marketing system as a whole. The present study confirmed that hides and skins brought to markets have quality problems due to disease, flay defect and injury. Livestock diseases, as revealed by farmer respondents were found to be the major cause of hide and skin defect which resulted due to poor husbandry practices. This finding is similar to Zewdu (1998) and Ahmed (2000) who states defects including flay defect, improper shape, injury, diseases and parasites, as well as storage and transport conditions down-grade the quality of the raw material. In addition, the current result is similar to other finding (Mulat, 1999; Girma, 2002) revealed that the main defects attributed to quality deterioration were flaying defect, injury, and putrefaction (due to delayed care). Such major problem may arise from lack of awareness on the management and handling of the raw materials. It may also be the result of poor live animal handling and inadequate veterinary care.

CONCLUSIONS AND RECOMMENDATIONS

Concusively, it was observed that there are a number of pre- and post-slaughter defects affecting the quality of the raw materials. The grades given to at least goat skin at wet blue stage were low ranging between 3 and 5 for most of them and no skin was in grade one and rejects were prevalent. On the other hand, physico-chemical parameters indicative of natural characteristics of the skins have revealed that despite the defects observed earlier, the goat skins tested performed well on most of the measurements. This suggests that if those defects caused by management problems are minimized, the skin will have a better quality. There were some problems related to marketing of hide and skins that need the attention of all stakeholders. Easy access to market and market information and better price offer are essential to improve the transaction.

Therefore, based on the aforementioned conclusion, the following points are recommended:

(1) Since most of the defects observed can be minimized or avoided through careful management of the animals, the hides and skin derived from them, continuous awareness creation and trainings must be given to livestock holders and development agents.
(2) Installation of differential price offered based on defined quality criteria will encourage producers to give due attention to quality.
(3) Encourage and incentivize legal hide and skin traders to get closer to the source so that fresh products are collected and farmers get better price information and offer.
(4) Since it has been shown that apparently normal goat skins were found to have a number of defects at wet blue stage of processing, visual inspection alone does not guarantee selection of raw materials for quality. Hence, better techniques should be developed if differential price offer based on quality should be installed.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Local sheep and goat reproductive performance managed under farmer condition in Southern Ethiopia

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Sheep and goats represent an important component of the farming system by providing about 12% of the value of livestock products consumed and 48% of the cash income generated at the farm level. Although diverse sheep and goats resources are found in Ethiopia, their productivity is low; the sector has not received a great deal of attention from scientists, administrators and legislators. Strategic recording and documentation of the performances of the animals in their native environment under farmer's condition is very essential. Current survey study was conducted in Dwaro zone, Southern Ethiopia to assess productive and reproductive performance of sheep and goat kept under framers management condition. Primary data were collected from 270 household selected randomly, while secondary data from relevant written documents. Survey result showed that ewes and does were weaned on average at age of 126.2±1.44 and 145.5±1.48 and 249.0±3.10 days in order and weaning age was significantly longer in highland and midland as compared to lowland whereas ewes age at puberty does not vary significantly across agro-ecological zone but does age at puberty is significantly shorter in highland. In addition, the finding indicated that age at first lambing and kidding was 408.0±3.32 and 393.5±3.05 days, respectively. Age at first lambing was not significantly ($p>0.05$) affected by agro-ecological zones while age at first kidding of does was significantly ($p<0.05$) longer in lowland (408.6±7.75 days) as compared to midland (385.6±4.31 days) and highland (386.2±0.83 days). Furthermore, survey result revealed that mean kidding and lambing interval was 269.9±3.08 and 269.0±2.89 days, respectively and kidding interval was significantly shorter in highland (263.5±6.0 days) and midland (264.0±5.89 days) relative to lowland (281.7±3.70 days), whereas lambing interval was not affected by agro ecological differences. Furthermore, the survey pointed out that household in the study area slaughtered sheep and goat at mean age of 258.1±4.39 and 255.6±2.49 days in sequence. Lowland household were preferred to slaughter sheep and goat at younger age as compared to midland and highland household for both species that preferred slaughtering of sheep and goat at older age. Feed and other related management improvement and implementing strategic breed improvement is the area that need further work in the future.

Key words: Age at first kidding, lambing interval, weaning age, Dawro.

INTRODUCTION

Small ruminants are widely reared in a crop-livestock farming systems and are distributed across different agro-ecological zones of Ethiopia (Adane and Girma, 2008). The total population of goats and sheep in

Ethiopia is estimated at 30.2 and 30.7 million, respectively and each of them (99.7%) are indigenous (CSA, 2017). At the national level, sheep and goat account for about 90% of the live animal/meat and 92% of skin and hide export trade value. Sheep and goats represent an important component of the farming system by providing about 12% of the value of livestock products consumed and 48% of the cash income generated at the farm level (FAO, 2004).

Although diverse sheep and goats resources are found in Ethiopia, their productivity is low; the sector has not received a great deal of attention from scientists, administrators and legislators (Girma et al., 2000). The research approach has not also invited the end users for active participation. Improvements were too slow due to lack of identifying the actual on-farm situations and weighting the socioeconomic and cultural benefits of the animals for the poor farmers. Farmers do make decisions not only from the point of view of profitability, but also security, income generation and cultural values (Tatek et al., 2004). Strategic recording and documentation of the performances of the animals in their native environment under farmer's condition is very essential for understanding productivity of animal under a given situation. Monitoring of the productive, reproductive and economic performance of small ruminants and their existing level of integration with crop production and other livestock keeping is required to capture a full picture of their contribution and thereby verifying possible intervention areas (Getahun, 2008). In line with this in Dawro zone, Southern Ethiopia, the information of productive and reproductive performance of sheep and goat is scarce. Thus, there is need for compiling of information and understanding the existing condition is compulsory to identify priority of intervention and to plan implementation ways accordingly. Therefore, the current study was undertaken to asses productive and reproductive performance of local sheep and goat managed under farmer condition in Dawro zone, Southern, Ethiopia.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Dawro zone, Southern Ethiopia. Dawro zone is located at a distance of 512 km far from Addis Ababa. The study area has an altitude ranging from 501 to 3000 m above sea level, mean annual rainfall varying between 1201 and 1800 mm and the mean minimum and maximum annual temperatures of 15.1 and 27.5°C, respectively. The study zone has five districts/woredas distributed in three agro-ecological zones; lowland or kola (55.6%), midland or weinadega (41.4%), and highland or dega (3%). Mixed crop-livestock farming system, involving the production of cereals and different livestock species is predominantly practiced (Southern Regional State Investment Bureau, 2011).

Sampling techniques and sample size

Purposive and random sampling methods were employed for the study. At the first stage, to make sampling system representative of the zone, three woredas or districts namely, Mereka district from highland, Loma from midland and Gena Bosa from lowland were selected purposively based on the number and intensity of livestock production and accessibility. At the second stage, by employing random sampling from each of selected districts, three representative peasant associations (PAs)/kebeles (lower administrative structure) were randomly selected. At the third (finally) stage, a total of 270 respondents or 90 respondents from each district were included purposively randomly for interview.

Data sources and data collection method

Both primary and secondary sources of data were used for the study. To collect the primary data, a semi-structured questionnaire was designed, pre-tested and then modified for appropriateness before the actual data collection commenced. Experienced numerators were recruited and trained to facilitate this task of primary data collection under the close supervisions of the researcher. To reinforce the primary data, direct observation and informal interview were carried. The secondary data was collected from different office of study zone, selected districts' and other relevant sources.

Data analysis

Statistical package for social science (SPSS) version 20 was used to analyze the collected data. The difference between means was separated via LSD and Tukey HSD at p<0.05 or 95% of confidence interval.

RESULTS AND DISCUSSION

Reproductive performances of sheep and goat

For each of reproductive performances, the respondent number varies due to the fact that the respondents forwarding their opinion for each parameter vary and all respondents could not respond for each parameter. Moreover, productive performance of sheep and goat was separately discussed except slaughter age.

Reproductive performance of sheep

Weaning age: Overall mean (mean ± standard error [SE]) of weaning age of lamb at different agro-ecological zones in the current study is 126.3±1.440 days (Table 1). Weaning age of lamb in lowland agro-ecology (119.3 ±

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Table 1. Reproductive performance of sheep in the study area.

Parameter (days)	Agro ecological zones (AEZs)			Overall (Mean±SE)	p value
	Lowland* (Mean±SE)	Midland* (Mean±SE)	Highland* (Mean±SE)		
Slaughter age	83 (200.9±2.06)[b]	79 (280.2±1.82)[a]	84 (292±10.32)[a]	258.1±4.39	0.00
Weaning age	83 (119.3±3.39)[b]	84 (129.2±2.01)[a]	85 (130±1.49)[a]	126.2±1.44	0.02
Age at puberty	77 (246±2.16)	82 (251±6.01)	84 (249±6.56)	249.0±3.10	0.86
AFL	79 (412±3.05)	78 (411.4±4.23)	85 (400.7±8.11)	408.0±3.32	0.27
LI	82 (270.2±0.73)	80 (268.3±4.06)	85 (268.45±6.55)	269.0±2.89	0.95

[a-b]Mean with row having different supper script is significantly different at p<0.05; AFL: Age at first lambing, LI: lambing interval, SE: standard error. *Number of respondents.

3.39 days) is significantly (P<0.05) shorter in compression with midland (129.2±2.01 days) and highland (130.3571 ±1.49 days).

Age at puberty: Age at which sheep shows the willingness to mate with ram for the first time is shown in Table 1. As indicated in Table 1, on average, ewes show sign of first heat for the first time at age of 249.0 ±3.10 days and this age was not significantly (P>0.05) affected by agro-ecological zones. Contrary to the current finding, Assen and Aklilu (2012) found that sheep in lowlands attain age of sexual maturity slower than highland. Average age at puberty of sheep in the current study area is shorter than the repot of Mukasa and Lahlou (1995) who reported that Menze sheep in central highland of Ethiopia attain puberty at 300 days and weight of 16.9±0.1 kg or 56% of mature body weight. But longer age at puberty is also reported by Assen and Aklilu (2012), who reported 8.99 ± 2.5 months.

Age at first lambing: Age at first lambing of sheep is significantly (P<0.05) different between agro-ecologies. Age at first parturition was the shortest in highland (400.7±8.11 days), while significantly longer time is taken by sheep age at first parturition in lowland (412.3±3.0505 days) relative to midland 411.4±4.23 days). This shows that the highland condition, that is, availability of feed and favorable environmental temperature might be the prominent factors that made the highland sheep to have the shortest age at first lambing. Similar to the current finding, Assen and Aklilu (2012) observed that the age at first parturition of sheep in highland is significantly shorter than midland and lowland agro-ecological zones. The average mean (408.0± 3.31 days) age at first parturition of the current study is very close to the age at first parturition reported by Belay and Hile (2009) and Assen and Aklilu (2012) who reported 404±65.4 days and 13.2±3.1 months or 418 days for native sheep managed traditional in Jimma and Tigray zones in respective order. However, Sisay et al. (2014) and Gebregiorgis et al. (2016) reported age at first lambing of approximately two times, that is, 731.67±0.3 days of the current finding for sheep managed under government ranch, private ranch and private farm (744±8.5 days) for Menze sheep, respectively. Whereas Mengiste et al. (2011) reported 1.3 times of the current age at first lambing (464.2 ± 140.0 days) for Washara sheep. On the other hand, as compared to the current finding, shorter age at first lambing of 354 and 360 days was reported for Arsi and Horro sheep in order (Solomon et al., 2010).

Lambing interval (LI): Lambing interval of ewe in the current study does not vary significantly across agro-ecological zones. But, a trend of lengthy in a LI was observed as someone go from highland to lowlands which might be due to differences in feed condition, health, season of lambing, etc. The overall mean of LI (269.0 ± 2.89 days) is very close to LI reported for traditionally managed sheep in Ethiopia and order than others methods in Ethiopia (Berhanu and Aynelam, 2009; Assen and Aklilu, 2102; Jahan et al., 2013; Sisay et al., 2014; Gebregiorgis et al., 2016). In addition, for various native sheep from different countries, 252.3 days, Assen and Aklilu (2012) for Ethiopian native sheep (196.5 days), Hassen and Tesfaye (2011) for native Bangladesh sheep (247.7 ± 49 days), Poon (2008) for Indian indigenous sheep which is shorter than the current LI, were also reported. On the contrary, very long LI that reaches up to 365 days is also reported for different sheep (Seabo et al., 1996). Obviously, variation in LI cannot be out of the environment and animal factors. Thus, there is variation in feed availability, management and mothering ability and breed of sheep across parts of the country and the world too. Overall, the results in this study is in agreement with some estimates in Africa which has been estimated under village conditions that ranged from 254 to 366 days in the semi-arid zone and 214 to 322 days in the humid zone (Abass, 1995).

Reproductive performance of goat

Weaning age (WA): Weaning age is the age at which kid stops suckling of its mother (doe). It is commonly affected by ability of mother to nurse her young and environments revealed that the WA of the kid significantly (P>0.05)

Table 2. Reproductive performance goat in the study area.

Parameter (days)	Agro ecological zones			Overall	p value
	Lowland* (Mean ±SE)	Midland* (Mean ±SE)	Highland* (Mean ±SE)	(Mean ±SE)	
Slaughter age	83 (217.6±3.95)^{b}	79 (259.3±1.05)^{a}	83 (291.9±1.05)^{a}	255.6±2.49	0.00
Weaning age	83 (136.0±2.88)^{b}	83 (151.8±2.10)^{a}	82 (149.0±2.29)^{a}	145.5±1.48	0.00
Age at puberty	73 (230.0±6.34)^{a}	83 (227.8±2.63)^{a}	85 (211.6±4.38)^{b}	222.6±2.67	0.00
AFK	73 (408.6±7.75)^{a}	83 (385.6±4.31)^{b}	85 (386.2±0.83)^{b}	393.5±3.05	0.00
KI	86 (281.7±3.70)^{a}	87 (264.0±5.89)^{b}	79 (263.5±6.0)^{b}	269.9±3.08	0.02

$^{a-b}$Mean with row having different supper script is significantly different at p<0.05; AFK: Age at first kidding; KI: kidding interval; SE: standard error. *Number of respondents.

affected by agro-ecological zones, that is, goat in lowlands (136.0 ± 2.88 days) hurriedly prevent kids suckling as compared to midland (151.8±2.10 days) and highland (149.0 ± 2.29 days) goats that allow kids to suckle her for longer time (Table 2). The shorter or earlier weaning of desert or lowland goat might be due to low milk yields or mechanism used by doe to sustain her life that might be harmed or lost due double effect, that is, low availability of feed and suckling by kids. Most probably high mortality of kids in lowland is due to early weaning age. In general, the current average WA (145.5 ± 1.48 days) is similar with the weaning age reported by Assen and Aklilu (2012) who reported weaning age of 4.75 ± 1.21 months for indigenous goat in Tigray zone, Northern Ethiopia.

Age at puberty: Age at puberty in doe kid is the age at which doe kid ovaries and reproductive hormones starts to communicate through order of hypothalamus and pituitary hormone or simply it is the time at which first heat is seen in doe kid or female goat. The present study revealed that in the study districts, on average, female goat reaches age of sexual maturity around 222.6±2.67 days. The age at puberty is insignificant (P>0.05) among agro ecological zones (Table 2). Statistically, age of puberty trend seems to increase with decrement of altitude. Current finding is shorter than the report of Weldeyesus and Rohotash (2018) who reported that about 12.7 months for Maefur goat breed managed under traditional management in Erob district, East Tigray. Most of the goats may often reach puberty without having achieved an adequate physical growth to support reproduction and first ovulation may not necessarily coincide with first estrus depending on nutritional status and breed (Greyling, 2010).

Age at first kidding (AFK): Mean of AFK of the study area goat is shown in Table 2. As indicated in Table 1, AFK of lowland goat (408.6 ± 7.75 day) is significantly higher than AFK of midland (385.6 ± 4.31 days) and highland (386.3 ± 0.837), but insignificant between midland and highland agro-ecological zones (Table 2). Longer AFK, in lowland might be due to longer age at puberty and delay to conceive pregnancy and lighter weight which may result predominantly due to feed shortage. Overall, mean AFK of the current study (393.4 ± 3.05 days) is comparable with mean AFK of central highland goat (407.9 days) (Mengistie et al., 2013), but longer than AFK of crossbred Abergelle goat (8.22 months or 246.6 days) (Shumuye et al., 2014), and Arsi-Bale goat (19.94 months) (Dadi et al., 2008). Most of sub-Sahara Africa goats reach AFK with a range of 303 and 556 days (Wilson, 1984). Thus, the goats in the study area are averagely productive. Because goat that starts kidding at younger age can produce more offspring than goat that starts kidding at older age, hence more productive and economical. Kidding makes the beginning of production (Zarkawi and Al-Daker, 2013). Age at first kidding is an important indicator in determining sexual maturity and life time productivity in does (Deribe and Taye, 2014).

Kidding interval (KI): Kidding interval is one of the major components of reproductive performance that influences productivity (Daribe and Taye, 2014). Current result revealed that the KI is statistically significant between agro-ecological zones, that is, lowland goats have longer KI when compared with midland and highland goats (Table 2). In close agreement with the overall current mean of KI (270 ± 3.08 days or 9 months), Daribe and Taye (2014) reported 289 ± 17.03 days of KI for Abergelle goat managed under traditional management. Mengistie et al. (2013) reported 307.9 ± 14.20 days for central highland goats managed under traditional management. Contrary to current finding, higher (greater or equal to one year) KI for goats managed under traditional management were reported from different areas of the country by many scholars (Assenet al., 2012; Yishaket al., 2013; Mohammed et al., 2015). In addition, shortest kidding interval that ranges 3.84 to 8.5 months was reported for native Ethiopian goat breed (Jemal, 2008; Belay and Greet, 2012; Netsanet et al., 2016).

Slaughter age of sheep and goat

Slaughter age is the age at which animal can give average yield and quality meat. The slaughter age can vary from country to country and even within a given country due to variation in culture, religion, reason of slaughter, and market weight of a given area. As a result, it is difficult to give range of age of slaughter. These might be the result why slaughter age was significantly different between agro-ecological zones in the current study. As shown in tables 1 and 2, people in lowland area slaughter sheep and goat at age (200.9±2.06 and 217.6±3.95 days) as compared to people living in midland and highland who slaughter goat and sheep relatively at younger age. The increment in days of slaughter as someone go from lowland to highland might be the preferences of highland people to white (fat) meat as compared to lowland people who seem to prefer lean (red) meat. In addition, the reasons why in lowland goat slaughter at younger age might be to limit shortage of feed that commonly occur in drought season in separate conditions. In comparison with the current result for slaughter age of sheep and goat, Assen et al. (2012) reported shorter mean slaughter age of 7.55 ± 2.27 and 7.55 ± 2.39 months for sheep and goat in order. Different from the present survey study, the same author observed that the average slaughter age of sheep and goat in Tigray zone, Northern Ethiopia is not significant between AEZ. But a trend of slaughter age increase from lowland to highland in his study was observed.

CONCLUSION AND RECOMMENDATION

The study shows that in the study area, local sheep productive performance is lower particularly in age at puberty, age at first lambing and better relatively in weaning age and lambing and kiding interval. Overall, productive performance of sheep and goat in lowland area was lower in relation to midland and highland. Thus, encouraging the positive productive performance and improvement of deficiency in other productive, particularly, in lowland area through feed and other related management improvement and implementing strategic breed improvement is the area that needs further work in the future.

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Influence of dietary wood charcoal on growth performance, nutrient efficiency and excreta quality of male broiler chickens

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Dietary wood charcoal can be a potential low-cost feed supplement for the improvement of performance in broiler chicken production, while reducing loss of nutrients through birds' excreta. However, it has no nutritive value and excess feeding may lead to constipation and thereby hamper birds' production performance. An experiment was conducted with a total of 24 male broiler chickens which were subjected to a commercial broiler finisher diet with 0, 1.5, 3, and 6% wood charcoal (on a dry matter basis), respectively. This was to ascertain the level of dietary wood charcoal that can be included in a commercial broiler feed without negative effects on production performance of broiler chickens, nutrient utilization and losses through birds' excreta under adverse climatic conditions in Northern Ghana. Birds' feed consumption, body weight gain, as well as excreta quality were assessed for four days. Results showed that dietary wood charcoal can replace up to 6% of a commercial broiler chicken feed without negative effects on growth performance, nutrient utilization and excreta consistency, while reducing the phosphorous concentration in broiler excreta. Future research should analyze the long-term effect of feeding charcoal on performance and health of laying hens.

Key words: Broiler chickens, dietary wood charcoal, nutrient utilization, production performance, excreta quality.

INTRODUCTION

Poultry production is the fastest growing livestock sector in Ghana (FAO, 2005). However, high feed costs increase the overall cost of production for poultry keepers which could negatively affect its economic sustainability (Sumberg et al., 2017). One of the means of reducing feed cost is to increase the efficiency of feed nutrient

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utilization. However, increase in temperature reduces the efficient utilization of feed required for optimum body weight of birds (De Moura et al., 2015).

The reported body weights of broiler chickens in Ghana typically are 2.6 to 2.7 kg after nine weeks with a feed conversion rate of 3.3 to 3.6 at the finisher phase (Oppong-Sekyere et al., 2012). Charcoal has been proposed as feed additive to stimulate feed intake and digestion, thereby enhancing growth performance of broiler chickens in Iran, Cameroon and Poland (Khadem et al., 2012; Kana et al., 2011; Majewska et al., 2011). In pigs, it has been demonstrated that charcoal reduced fecal gas emissions (Chu et al., 2013), and hence might be an option to reduce negative environmental effects of pig production. Finally, charcoal has a good adsorption capability of toxins and therefore has the potential to improve birds' health (Khadem et al., 2012; Rafiu et al., 2014).

Notwithstanding the potential positive effects, feeding charcoal to poultry might also have negative consequences for animals' health and feeding behavior, growth performance and nutrient availability in manure. Charcoal has no nutritive value and may cause constipation if fed in excess. In goats, Quaranta et al. (2013) demonstrated that the fecal consistency changed from normal to hard when goats consumed diets with over 5% activated charcoal.

Furthermore, the fecal nitrogen content decreased, while its carbon content increased with higher levels of supplemented activated charcoal (Quaranta et al., 2013). There is lack of research that systematically evaluates the effect of different levels of dietary wood charcoal in a commercial broiler feed on the accretion and utilization of feed nutrients by broiler chickens, and on the quality of birds' excreta.

Therefore, this study aimed at ascertaining what level of dietary wood charcoal can be included in a commercial broiler diet without negative effects on production performance, as well as nutrient utilization and losses through birds' excreta under adverse climatic conditions in northern Ghana.

MATERIALS AND METHODS

An experiment was conducted in March 2016 at the Poultry Unit of the University for Development Studies (UDS) in Tamale, Northern Region, Ghana. The study was closely supervised by a Veterinarian and followed the regulations for Animal experiments of UDS. Ethical clearance was obtained on the 14th January 2016 from UDS (code number ANS/FOA/02/14012016).

Experimental birds

Twenty-four 4-week-old healthy male Cobb 500 strain broiler chickens of similar body weight were randomly selected from the experimental flock of UDS and transferred to individual cages with a wire floor (1.6 x 1.4 x 1.6 m^3) in a separate house which paved way for natural ventilation. Artificial source of light (10 lx) was provided in the house at night from 18:00 to 7:00 h to encourage feeding. An adaptation period of 14 days allowed the birds to adjust to the new surroundings and diet. The experimental period with data collection lasted four days beginning when birds were 42 days old.

Dietary treatments

Each experimental bird was randomly assigned to one of four experimental diets, each replicated six times. The dietary treatments were based on a commercial finisher feed with vitamin premix and added phytase. The analyzed chemical composition of the commercial broiler feed was 907 g organic matter (OM)/kg, 192 g CP/kg, 397 g carbon (C)/kg and 8 g phosphorus (P)/kg, on a dry matter (DM) basis (Table 1). Wood charcoal was purchased from Tamale market, ground and sieved with 1 mm sieve. The ground charcoal contained 880 g DM, 874 g OM/kg DM, 721 g C/kg DM, 43 g CP/kg DM and 1 g P/kg DM (Table 1). It was thoroughly mixed with the feed, replacing 0% (T-0%), 1.5% (T-1.5%), 3% (T-3%) and 6% (T-6%) of the commercial broiler feed, on a DM basis. All dietary treatments covered 1.2 times the N-corrected metabolizable energy (AME_n) requirements of the experimental birds (NRC, 1994) (Table 1). For the wood charcoal, we assumed energy content of 0 kcal. Feed was supplied daily at 07:00 h and clean water was provided *ad libitum*.

Growth performance, excreta color and consistency

Birds were weighed before feeding on day 42 (initial body weight) and day 46 (final body weight).

Total weight gain (g/bird) = Final body weight (g/bird) – Initial body weight (g/bird)
Daily feed consumption (g/bird) = Daily feed leftover (g/bird) – Daily feed offer (g/bird)
Overall feed conversion rate = Total feed consumption (g/bird) / Total weight gain (g/bird).

Feed leftovers included all the remaining feed in the feeders and on the plastic sheets below the cages after 24 h. Mortality of birds was recorded as it occurred. Birds' excreta were collected daily from the plastic sheets placed under the wire mesh floor of the cages using the total excreta collection method before feeding. For each cage, five fresh dropping samples were assessed for color and consistency daily. Color assessment was based on a grey scale and value finder (Color Wheel), with graduation 1 for 100% black up to 10 for white. The dropping consistency was determined by feeling fresh dropping samples in between the index finger and the thumb wearing latex gloves. It was given a value from 1 to 4, with 1 being very soft (very watery, dropping flows very easily), 2 as soft (watery yet slightly more viscous than consistency 1), 3 as medium (firm yet does not maintain shape very well after it drops, also shape collapses easily when held with little pressure in between thumb and index finger) and 4 as hard (very firm, maintains perfect conical shape after it drops, sticks together when held between thumb and index finger). A composite score was calculated as mean from color and consistency values of each cage.

Nutrient accretion and utilization

Excreta, feed, and charcoal samples were oven dried (80°C until constant weight), weighed, pooled, and subsampled for each cage. For two cages, subsamples of excreta were missing, resulting in a total of 20 subsamples (replicates), five for each dietary treatment. Subsamples of feed, charcoal, and excreta were ground to pass a 1 mm sieve (Cyclotec, FOSS GmbH, Hamburg, Germany) and

Table 1. Analyzed chemical composition (g/kg DM) of experimental diets and dietary wood charcoal used fed to male broiler chickens.

Composition	Wood charcoal	Dietary treatments[1]			
		T-0%	T-1.5%	T-3%	T-6%
Dry matter (g DM/kg fresh matter)	880	881	893	899	913
Organic matter	874	907	925	921	922
Crude protein[2]	43	192	203	202	188
Carbon	721	397	437	442	447
Phosphorus	1	8	7	8	7

[1]T-0%: Commercial broiler feed with 0% wood charcoal (WC), T-1.5%: Commercial broiler feed and WC replacing 1.5% of the commercial broiler feed, T-3%: Commercial broiler feed and WC replacing 3% of the commercial broiler feed, and T6%: Commercial broiler feed and WC replacing 6% of the commercial broiler feed (on a dry matter basis); [2]Crude protein was calculated as nitrogen x 6.25. According to the manufacturer's declaration, the commercial broiler feed contained 2950 kcal metabolizable energy/kg.

Table 2. Growth performance of male broiler chickens fed different substitution levels of charcoal in commercial broiler feed (day 42-45).

Parameters	Unit	Dietary treatments[1] (mean)					Overall			Kruskal Wallis
		T-0%	T-1.5%	T-3%	T-6%	SEM[3]	Median	Min.	Max.	p-value[4]
Replicates[5]	N	5	6	6	5		-	-	-	-
Initial body weight	G	1645	1631	1598	1762	44.4	1611	1396	2096	n.s.
Final body weight	G	1998	1936	1931	2082	56.8	1929	1577	2594	n.s.
Weight gain	g/bird	353	305	333	319	20.0	321	181	498	n.s.
Feed consumption	g FM[2]/bird	499	537	535	573	22.6	502	385	765	n.s.
Feed conversion rate	g/g	1.5	1.8	1.6	1.9	0.08	1.7	1.2	2.8	n.s.

[1]T-0%: Commercial broiler feed with 0% charcoal, T-1.5%: Commercial broiler feed with 1.5% charcoal, T-3%: Commercial broiler feed with 3% charcoal, T-6%: Commercial broiler feed with 6% charcoal; [2]FM: Fresh matter; [3]SEM: Standard error of the mean; [4]Probability values are indicated as *P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001. n.s. not significant P > 0.05; [5]Mortalities were observed during the adaptation period.

analyzed in duplicate in the laboratory of Universität Kassel in Witzenhausen, Germany. The dry matter (DM) and organic matter (OM) concentrations were determined following the standard procedures of the Association of German Agricultural Analytic and Research Institutes (VDLUFA, 2006). OM was calculated as the difference between DM and crude ash. The vanadate-molybdate-method was used to determine the P content (Hitachi U-2000 photometer, Hitachi Co. Ltd., Tokyo, Japan), and the C and N concentrations were analyzed with a C/N-TCD analyzer using DUMAS combustion (Elementar Analysensysteme GmbH, Hanau, Germany). The N concentration was multiplied by the factor 6.25 to obtain CP concentrations (AOAC, 1990). The values obtained were used to compute accretion and utilization of DM, C, N and P by broiler chickens. Accretion (g/day) was calculated as difference between consumption (g/day) and output in total excreta (g/day), while utilization represented accretion as a percentage of consumption.

Statistical analyses

Data were analyzed with R version 3.3.0 (R Core Team 2016). Data were assessed for conformity to normal distribution using Shapiro-Wilk tests and homogeneity of variances was tested with the Bartlett's test. Residuals of data that were not normally distributed and/or data with non-homogeneous variances were analyzed using Kruskal Wallis tests. Other data were analyzed using a one way analysis of variance (ANOVA). Differences were considered significant if $P \leq 0.05$. All graphs were created by the aforementioned software package.

RESULTS AND DISCUSSION

Effects of dietary wood charcoal on growth performance of male broiler chickens

The initial and final body weight of experimental birds and hence the average daily body weight gain were similar, indicating that feeding wood charcoal had no effect on broiler chickens' growth rate (P > 0.05). Similarly, the total feed consumption did not differ across dietary treatments (P > 0.05), resulting in comparable, feed conversion rates across dietary treatments (P > 0.05; Table 2). Also Kana et al. (2011) and Majewska et al. (2011) showed no improvement of feed efficiency in broiler chickens when charcoal was included in the diet, but recorded an increase in body weight gain with the inclusion of charcoal of up to 0.4 and 0.3%, respectively. In contrast, Bakr (2008) demonstrated that wood charcoal

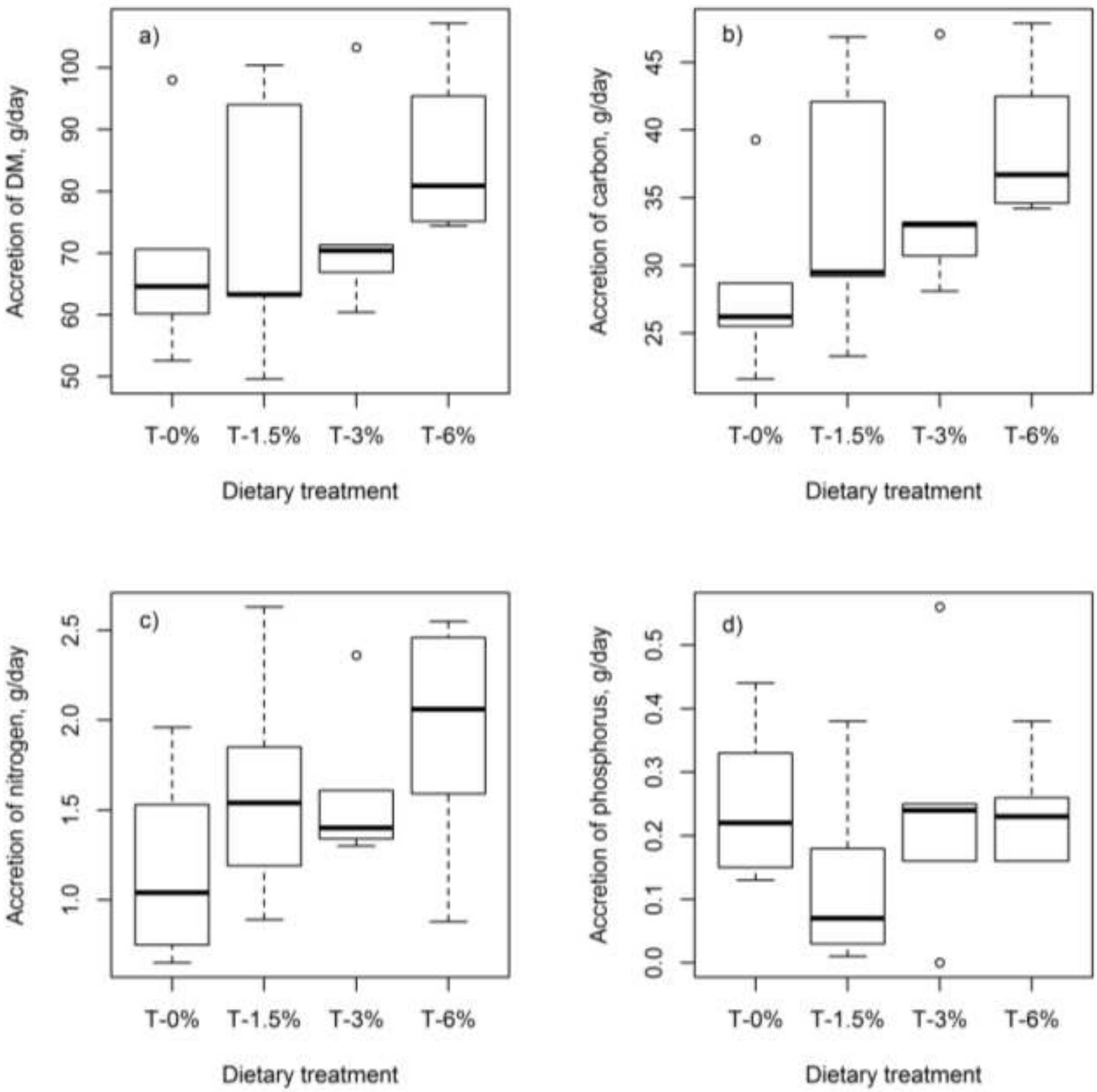

Figure 1. Accretion of a) dry matter b) carbon, c) nitrogen and d) phosphorous (all in g/day; P > 0.05, ANOVA) by broiler chickens fed with different substitution level of charcoal using total excreta collection. T-0%: Commercial broiler feed with 0% charcoal, T-1.5%: Commercial broiler feed with 1.5% charcoal, T-3%: Commercial broiler feed with 3% charcoal, T-6%: Commercial broiler feed with 6% charcoal. n = 5 replicates for each dietary treatment.

increased the feed conversion efficiency and other growth performance parameters in broiler chickens if the inclusion rate does not exceed 2%. However, this effect was age-dependent, limited to birds younger than 29 days, which might explain the missing effect in this study. Finally, Odunsi et al. (2007) observed a negative impact of feeding wood charcoal on growth performance of broilers and did not recommend dietary inclusion of wood charcoal.

Effects of dietary wood charcoal on nutrient accretion and utilization in male broiler chickens

The addition of dietary wood charcoal to broiler chicken finisher feed did not show any effect on the accretion of dry matter, carbon, nitrogen, and phosphorus of the birds (P > 0.05; Figure 1). Still, the dry matter, carbon and nitrogen accretion slightly increased with increasing level of dietary wood charcoal in the diet (DM: 69.2 g/day in T-

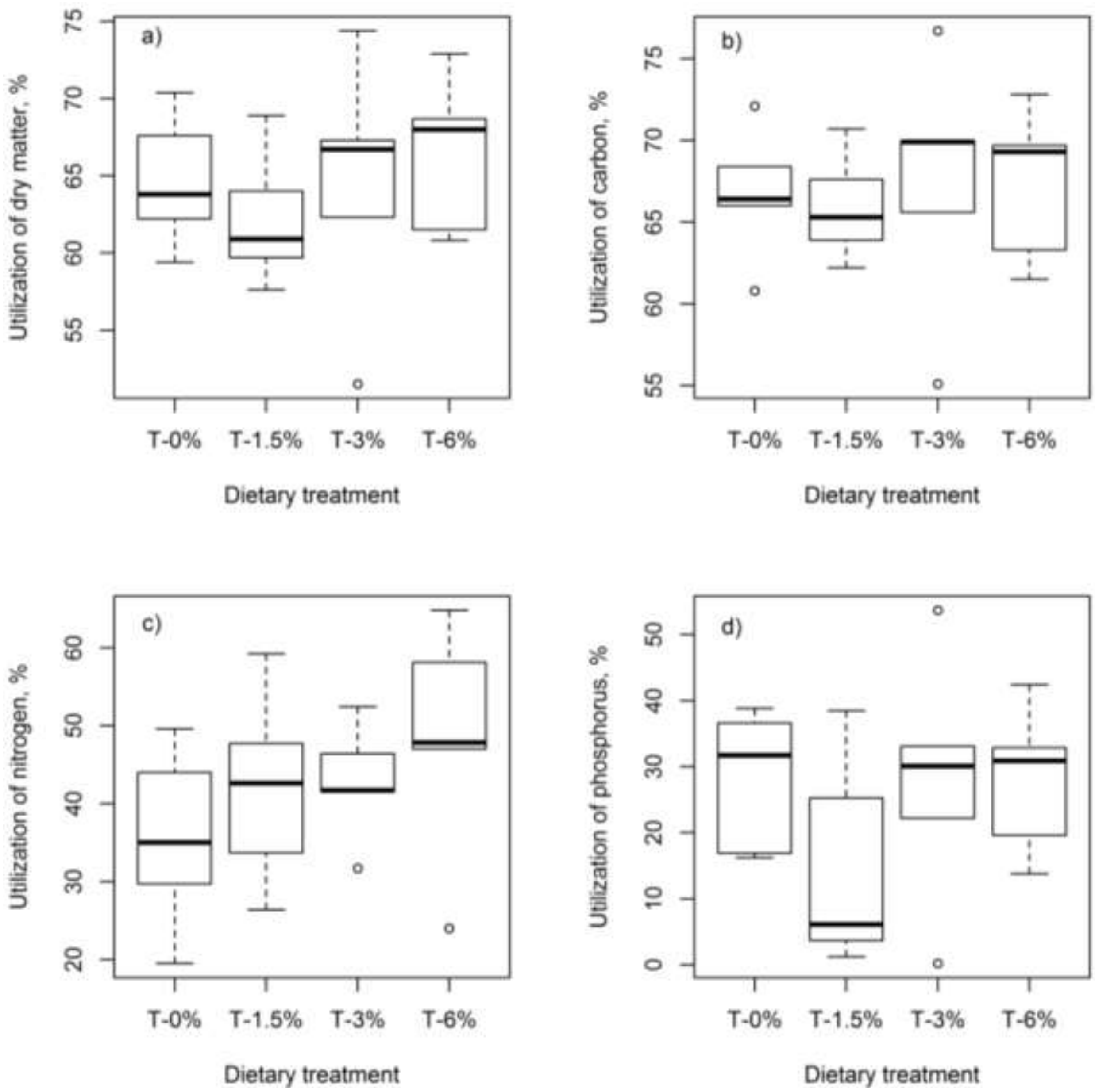

Figure 2. Utilization of a) dry matter b) carbon, c) nitrogen and d) phosphorous (all in %; P > 0.05, ANOVA) by broiler chickens fed with different substitution level of charcoal using total excreta collection. T-0%: Commercial broiler feed with 0% charcoal, T-1.5%: Commercial broiler feed with 1.5% charcoal, T-3%: Commercial broiler feed with 3% charcoal, T-6%: Commercial broiler feed with 6% charcoal. n = 5 replicates for each dietary treatment.

0%, 86.6 g/day in T-6%; C: 28.3 g/day in T-0%, 39.2 g/day in T-6%; N: 1.2 g/day in T-0%, 1.9 g/day in T-6%), while the phosphorus accretion remained constant at 0.25, 0.13, 0.24 and 0.24 g/day in T-0%, T-1.5%, T-3% and T-6%, respectively (SEM: 0.03 g/day). Accordingly, no effect on the nutrient utilization was observed (P > 0.05; Figure 2). The mean utilization of nutrients by broiler chickens fed T-0%, T-1.5%, T-3% and T-6%, respectively, was 64.7, 62.2, 64.4, and 66.4%, SEM: 1.24% (dry matter); 66.7, 65.9, 67.5, and 67.3%, SEM: 1.10% (carbon); 35.6, 41.9, 42.7, and 48.3%, SEM: 2.72% (nitrogen); and 28.0, 15.0, 27.9, and 27.9%, SEM: 3.31% (phosphorus). This is in accordance with a previous study of Oso et al. (2014) who concluded that the inclusion of dietary wood charcoal did not influence the apparent DM and crude protein digestibility of broilers. In the same study, however, the inclusion of charcoal into unpeeled cassava root meals could counterbalance the negative effect of dietary cyanide on the crude protein utilization. Similarly, the crude protein

Table 3. Chemical composition (g/kg DM; mg/kg DM for P) of total excreta of male broiler chickens fed with different substitution level of charcoal.

Variable	Dietary treatments[1] (mean)				SEM[2]	ANOVA
	T-0%	T-1.5%	T-3%	T-6%		p-value[3]
Replicates (n)	5	5	5	5	-	-
Organic matter	797	810	813	810	3.35	n.s.
Carbon	374[b]	394[ab]	404[a]	435[a]	5.54	***
Nitrogen	55.7	49.8	53.2	45.6	1.61	n.s.
Phosphorus	17.0[a]	16.0[ab]	15.1[b]	14.6[b]	0.30	**

[1]T-0%: Commercial broiler feed with 0% charcoal, T-1.5%: Commercial broiler feed with 1.5% charcoal, T-3%: Commercial broiler feed with 3% charcoal, T-6%: Commercial broiler feed with 6% charcoal; [2] SEM: Standard error of the mean; [3]Probability values are indicated as *P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001, n.s. not significant P > 0.05. Letters indicate significant differences within rows (P ≤ 0.05; Tukey HSD test).

Table 4. Consistency and color of total excreta of male broiler chickens fed with different substitution level of charcoal.

Variable	Dietary treatments[1] (median)						Kruskal Wallis
	T-0%	T-1.5%	T-3%	T-6%	Min	Max	p-value[2]
Replicates (n)	5	6	6	5	-	-	-
Color	7.4	5.7	4.4	2.2	1.2	8.0	**
Consistency	2.3	2.4	2.4	2.5	1.6	3.4	n.s.

[1]T-0%: Commercial broiler feed with 0% charcoal, T-1.5%: Commercial broiler feed with 1.5% charcoal, T-3%: Commercial broiler feed with 3% charcoal, T-6%: Commercial broiler feed with 6% charcoal; [2]Probability values are indicated as *P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001, n.s. (not significant) P > 0.05. Differences across dietary treatments could not be computed due to ties.

digestibility of broilers fed Aflatoxin infested diets was improved using charcoal as toxin binder (Rafiu et al., 2014) (Figure 1 and 2).

Effects of dietary wood charcoal on excreta quality of male broiler chickens

As could be expected, feeding charcoal increased the carbon concentration in total excreta by 5.3% (T-1.5%), 8.0% (T-3%) and 16.3% (T-6%), respectively, compared with excreta of birds fed with the dietary treatment withoutwood charcoal (T-0%) (P ≤ 0.05). Charcoal is inert and indigestible and therefore is excreted together with the undigested feed residues, as already argued by Al-Kindi et al. (2016). In contrast to the carbon concentration, the phosphorous concentration of the excreta decreased by 5.9% (T-1.5%), 11.2% (T-3%) and 14.2% (T-6%) in this study (P ≤ 0.05), while the organic matter and nitrogen concentrations of total excreta were not altered by substituting part of the commercial broiler feed by dietary wood charcoal (P > 0.05) as shown in Table 3. This is in agreement with Kutlu et al. (2001), who also detected a linear effect of dietary charcoal on the composition of excreta of broiler chickens, with the exception of the nitrogen concentration. It is also plausible that the reduction in phosphorous concentration in excreta was as a result of the change in gastro-intestinal tract microbiota, as evidenced by Prasai et al. (2016) in layers. Although the addition of charcoal had no additional influence on the phosphorus utilization by broiler chickens in the present study, the lower phosphorus concentration in excreta of birds fed high levels of dietary wood charcoal demonstrates the potential of dietary wood charcoal to increase the bioavailability of phosphorus bound in the phytin of poultry diets that is generally limited due to an insufficient production of endogenous phytase in poultry (Maenz and Classen, 1998). Lowering the phosphorus concentration in poultry manure that is usually high (up to 2.4%) (Bolan et al., 2010), might also reduce the risk of surface water contamination (Table 3). As could be expected there was a clear color change of birds' fresh excreta from light grey for birds fed with no wood charcoal, that is, T-0%, to very dark grey for birds fed with dietary treatment with the highest level of charcoal (T-6%) (P ≤ 0.01); however, the consistency of excreta was not influenced by the addition of charcoal and no signs of constipation or any health problem were observed in broiler chickens fed dietary treatments with wood charcoal (Table 4).

CONCLUSIONS

Dietary wood charcoal could replace up to 6% of commercial broiler finisher feed without negative effect on production performance, nutrient accretion and utilization, as well as excreta consistency of male broiler chickens. The use of wood charcoal as a broiler feed additive, particularly at 6% substitution level, reduced P in total excreta suggesting that wood charcoal could improve the phosphorus utilization in broiler chickens. Increased C excretion through feeding wood charcoal could potentially improve the poor soil quality in northern Ghana. Future research should analyze the long-term effect of feeding wood charcoal on performances and health of laying hens.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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