International Journal of Livestock Production

Volume 8 Number 6 June 2017
ISSN 2141-2448

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International Journal of Livestock Production (IJLP) (ISSN 2141-2448) is monthly (one volume per year) by Academic Journals.

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International Journal of Livestock Production

Table of Contents: Volume 8 Number 6 June 2017

ARTICLES

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Vol. 8(6), pp. 72-78, June 2017
DOI: 10.5897/IJLP2017.0368
Article Number: 11DB69964309
ISSN 2141-2448
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International Journal of Livestock Production

Full Length Research Paper

Influence of breed, season and age on quality bovine semen used for artificial insemination

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Received 2 February, 2017; Accepted 25 April, 2017

The success or failure of artificial insemination starts with the quality status of semen used, hence, this study aimed to investigate the effects of breed, season and year on bovine semen quality of the National Bull Stud of Rwanda kept at Masaka bull station, Rwanda. A total of 1475 semen samples were collected bi-weekly from nine bulls of Holstein Friesian (n = 3), Inyambo (n = 3) and Jersey (n = 3) breed using an artificial vagina. Semen volume, colour, concentration, mass motility, live sperm percentage and post-freeze motility were evaluated. Libido of the bulls at the time of semen collection was scored. Ejaculate volume, mass motility, individual motility, density and post freeze motility significantly differed ($p < 0.05$) among seasons of the year, bull breeds and age/year of collection. Friesian bulls had superior ($p < 0.05$) semen volume (5.76±0.08 ml) to that of Jersey (4.29±0.09 ml) and Inyambo (3.37±0.1 ml). However, Friesians had an inferior ($p < 0.05$) lighter coloured semen, with only 52.7% of Friesian samples having the preferred cream colour, as compared to 65.2% of Jersey and 64.9% of the Inyambo semen samples. Year of collection (2011 or 2012) and in essence age of the bull negatively affected ($p < 0.05$) all the parameters studied, with semen volume dropping from 5.16 to 5.10 ml, colour lightened from 62.8 to 54% of the samples being cream; mass motility fell from 2.98 to 2.65, while live sperm percentage in ejaculates dropped from 65 to 63%. Of the eight parameters studied, only post-freeze motility was not affected by passage of time. Semen collected during the October to December period had the best quality characteristics, though collections in the long rains (March to May) had comparable mass motility and post-freeze motility. Semen volume (4.61 ml per bull ejaculate) and post-freeze motility (39%) were poorest in the long dry season (January to February). In conclusion, the Friesian breed should be promoted at the bull station. Most semen should be collected during the rain season, particularly the short rains (October to November). Bulls below three years of age should be of focus.

Key words: Cattle, mortality, seasonality, semen evaluation, pedigree bulls.

INTRODUCTION

Artificial insemination (AI) is the most valuable breeding management tool available to cattle breeders to improve the genetic potential of their herds. The optimal use of genetically superior bulls through artificial insemination is highly dependent on precise seminal quality which allows for reasonable estimations of field fertility with normal or low-dose inseminations (Fuerst-Waltl et al., 2006; Christensen et al., 2011; Ahmed et al., 2016). There are factors determining the success of AI such as environmental seasonal variations and temperature (McDowell, 1972). In areas where seasonal variation in temperature occurs, sperm morphological characteristics were variable (Curtis, 1983; Mathevon et al., 1998; Brito, 2010). Mathevon et al. (1998) reported that the interaction between age and season could have a significant effect on the semen characteristics of Friesian bulls. seasonal factors, especially temperature, have an important effect on the spermatic production in most bulls, but the individual response to thermal stress is different. Detrimental effect on the spermatic parameters has been registered mostly in the warm seasons, during months with average temperatures of about 20°C. Numerous studies were dedicated to identification of the factors which affect the spermatic production and the quality of the semen. To date, some differences and even contradictions regarding the effect of the season on spermatic production were identified. Consequently, some studies (Mathevon et al., 1998 and Brito, 2010) demonstrated significant influence of season on the spermatic production, while some other studies did not detect any effect of season on the spermatic production (Brito et al., 2002; Girdhar, 2003; Vilakazi and Webb, 2004). Meanwhile, other researchers did observe the highest concentration and total number of spermatozoa occurs during the summer season (Stalhammar et al., 1989; Mathevon et al., 1998; Ghasemi and Ghorban, 2014).

Season of the year influences the secretion of luteinizing hormone (LH), the average concentration of testosterone in bulls, and the number of spermatozoa per ejaculate is consequently affected (Jimenez-Severiano et al., 2003). The study of Jimenez-Severiano (2003) also revealed that highest LH average values in young bulls were registered in spring and the lowest in the winter period and that average testosterone concentrations were also higher in spring and summer than in the cold season. The same effect was revealed in bulls of a beef breed from the tropical region, in which there was observed a depreciation of semen quality and a diminution of testicular dimensions in winter (Nichi et al., 2006). The optimal environmental temperature for spermatic production is estimated to range between 15 and 20°C (Parkinson, 1987). It is considered that not only the temperature registered in the day of semen collection affects the production, but also the temperature registered during the entire spermatogenesis period, until 70 days before collection. Furthermore, it was indicated that for young bulls, superior morphological characteristics were observed during the winter and spring as compared to summer and autumn. Dombo (2002) reported that the semen quality does not remain the same throughout the year, especially as the season changes and as the bull advances in age.

Many efforts have been made to improve milk production in Rwanda and a crossbreeding programme is being implemented on a large scale (Girdhar, 2003; MINAGRI, 2011). This programme is aimed to maximally depend on the use of artificial insemination both for small-scale/smallholder/zero grazer units, and for large scale dairy farms. The artificial insemination programme in Rwanda relies on both imported and in-country produced bovine semen, with a plan to produce most of the semen domestically. In tropical regions, semen output, quality and mating behaviour of bulls can vary from season to season, depending mainly on availability and quality of feed and climatic conditions. Therefore, this study aimed to study the influence of breed of the bull, season of semen collection and age of the bull on bovine semen quality of Friesian, Jersey and Inyambo bulls kept at Masaka Bull Station, Rwanda.

MATERIALS AND METHODS

Experimental animals and housing

A total of 1475 semen samples were collected from the National Bull Stud of Rwanda from three Holstein Friesian bulls (946 semen samples), three Jersey bulls (371 semen samples) and three Inyambo bulls (174 semen samples) maintained at the semen production facility at Masaka Bull Station. At the onset of the study, the breeder bulls were in good health status and were aged between three and seven years. Data recorded over a period of two years were used for semen quality evaluation. Bulls were housed individually in pens, which were constituted into two large sheds/barns. The sheds were designed conventionally, to provide sufficient natural cross-ventilation and to minimize heat stress. Each bull pen was facilitated with a water point and a feeding manger. The pens were provided with floor litter in form of dry grass to increase the comfort of the bulls.

Feeding and health management

The feeding requirements of animals were calculated according to their body weight, with daily feed Although the production system and marketing are offering on dry weight basis of 3% of body weight. The feeding regime per bull consisted of Napier grass and 5 to 6 kg of protein-energy concentrate mixture.

Water was provided *ad libitum* to the bulls via a water point. Regular vaccination was carried out; twice a year in June and December against hemorrhagic septicemia; and foot and mouth

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Table 1. Mean temperature recorded by Rwanda meteorological service.

Seasons	Maximum temperature (°C)	Average temperature (°C)	Minimum temperature (°C)
Long rain (March-May)	25	20	15
Long dry (June-September)	27	22	15
Short rain (October-November	26	21	15
Short dry (December-February)	26	21	15

Source: Rwanda meteorological service.

disease in February and September; and once a year in April against black quarter. Preventive measures against external and internal parasitic infestation were also undertaken three times a year. Multivitamins were given once a month by intramuscular injection.

Climate

The season condition of the study area was considered as indicated in Table 1.

Semen collection and processing

Semen collection was undertaken twice a week. Bulls to be used on a particular day went through preparatory measures including showering, drying and cleaning, brushing, grooming and half an hour exercise. The bulls were then allowed to mount a teaser bull and the semen was collected with the help of a pre-warmed (42 to 45°C) artificial vagina. Ejaculate volume was recorded directly from the graduated semen collection tube. Each ejaculate was examined for mass motility, individual motility and sperm concentration and ejaculates having less than 50% sperm motility were discarded. The fresh semen was then diluted depending upon microscopic evaluation of sperm concentration at 32°C with tris, citrate, fructose, egg yolk. All collections were performed early in the morning between 6.00 and 8.00 h. After collection, the tubes containing semen were immediately transferred from the collection room to the laboratory and placed in a water bath at 36°C to maintain the temperature of sperm cells. The characterizations of semen require laboratory tests and depend on norms and standards fixed by the management of the station. After the initial observations, the semen was diluted using andromed extender (AndroMed®, Tiefenbach, Germany).

Characteristics of semen after collection

The collected semen was firstly examined with naked eyes to observe the colour and was then confirmed from a published colour chart; and then the volume was read off from a graduated semen collecting tube. The semen was then transferred to a water bath at 33-36°C. Microscopic evaluation was done using a microscope (Minitube, Germany), for mass activity. Individual motility and determination of concentration was then done with a calibrated photometer (Minitube, Germany). Mass motility was then tested by placing a small drop of semen (approximately 5 µl) on a slide using a microscope at 10x magnification. Another small drop was deposited on the slide and carefully placing a cover slip over it and then was visualized at 40x to observe individual motility. A score was given on a hedonic scale of 0 to 4 for the mass motility and percentage for individual motility by each of three independent observer technicians. The scores were not significantly different and were then summed up and mean computed.

To continue the process, the minimum mass motility score needed was 3, and 60% for individual motility, also the colour was scored on a scale of 1 to 3 (Javed et al., 2000). Score 3 was given to semen with a high concentration of sperm cells, and this was characterized by a creamy consistence, and also marked as good semen. Score 2 was given to semen with tolerable concentration of sperm cell, and was characterized by a milky consistence. Score 1 was given to semen with a very low concentration of sperm cells; and characterized by a watery consistence. Score 0 was given to ejaculate without sperm cells and characterized by a clear watery consistence. The semen with score 0 and 1 was discarded.

Data analysis

The data were typed into spreadsheets of the MS-Excel software. Preliminary analysis was conducted using Chi-square procedure of statistical analysis system (SAS, 2004), to determine whether there were significant differences between the levels of the class variables. This was because the number of animals used as the samples were few and possibly, the small sub-class numbers could hinder the effects of the independent variables to be quantified. On finding significant differences (Table 2), further analyses particularly, least square means were then computed using the generalized linear models of statistical analysis system (SAS, 2004) and were separated using Duncan's multiple range test. The results were presented as means ± standard error of the mean (S.E.M.). Data on scrotal circumference was not collected hence correlation with semen volume could not be done.

RESULTS

The results showed that ejaculate volume, mass motility, individual motility and post freezing motility significantly differed ($p < 0.05$) among the three cattle breeds studied (Table 2). Friesian bulls had superior ($p = 0.001$) semen volume to that of Jerseys and Inyambo. However, Friesian bulls had an inferior ($p = 0.003$) semen colour score (3.12) to that of Jersey (3.31) and Inyambo (3.29), but the latter two did not differ (Table 2). Only post freeze motility was not affected by time factor. The short rain season (October to November) gave the best semen quality characteristics but was not significantly ($p=0.838$) better than the long rains except in mass motility and post-freeze motility. Semen volume (4.61) and post-freeze motility (38.51%) were poorest in the long rainy season (March to May) (Table 3).

The results of the study indicated a significant interaction between breed and season in the effect on ejaculate volume (p = 0.003), libido score (p = 0.0014),

Table 2. Least square means of various semen quality parameters as influenced by breed.

Parameter	n	Bull breed: Friesian (n = 946)	Jersey (n = 371)	Inyambo (n = 174)	GLM p-Value	χ^2 p-Value*
Volume (ml)	1468	5.76±0.08[a]	4.29±0.09[b]	3.37±0.1[c]	***	<0.001
Libido score	1463	3.14±0.01[a]	3.97±0.01[b]	2.81±0.03[c]	***	<0.001
Semen color (%)					*	<0.001
Creamy	854	52.7	65.2	64.9		
Milky	456	31.9	25.3	34.5		
Watery	62	4.3	5.4	0.6		
Yellowish	99	11.1	4.1	0		
Semen concentration (10^9 spz/ml)	1471	3.12±0.03[b]	3.31±0.05[a]	3.29±0.07[a]	***	<0.001
Mass motility (%)	1360	2.67±0.03[c]	3.05±0.04[a]	2.90±0.06[b]	***	<0.001
Individual motility (%)	1400	62.04±0.6[b]	68.14±0.9[a]	66.01±1.04[a]	***	<0.001
Live-dead Percentage (%)	1375	35.96±0.5[a]	29.37±0.7[b]	34.12±1.05[a]	***	<0.001
Post freezing motility (%)	762	40.43±0.5[b]	43.45±0.9[a]	42.20±1.1[a]	**	0.0012

[abcd] Values within the same column with different superscripts differed significantly { ***(p<0.001); **(p<0.01); * p<05)}. The Chi-square analysis was done at preliminary stage, to justify further ANOVA analysis.

Table 3. Influence of season on semen quality.

Parameters	Season[ϕ]: Long rain season (n = 274)	Long dry season (n = 380)	Short rain season (n = 401)	Short dry season (n = 389)	*P.* value
Volume (ml)	4.61±0.15[b]	5.31±0.12[a]	5.01±0.09[a]	5.28±0.13[a]	***
Libido score	3.05±0.04[b]	2.97±0.02[c]	3.0±0.09[c]	3.22±0.02[a]	***
Semen color (%)					
Cream (%)	59.5	53.5	67.5	49.7	
Milky (%)	35.6	34.4	21.2	36.6	
Watery (%)	4.9	3.8	5.0	3.1	
Yellowish (%)	-	7.0	6.3	9.8	
Semen concentration (10^9spz/ml)	3.14±0.08[b]	3.11±0.04[b]	3.36±0.04[a]	3.07±0.05[b]	***
Mass motility (%)	2.71±0.06[b]	2.58±0.04[c]	2.86±0.04[a]	2.94±0.04[a]	***
Individual motility (%)	65.29±1.17[a]	63.79±0.78[b]	62.09±0.98[a]	65.85±0.78[a]	**
Live-dead Percentage (%)	34.70±1.17[ab]	36.06±0.79[a]	32.7±0.74[c]	33.97±0.78[ab]	*
Post freezing motility (%)	38.51±1.41[b]	42.45±0.76[a]	42.85±0.78[a]	39.68±0.96[b]	**

[abcd] Values within the same column with different superscripts differed significantly { ***p<0.001); **(p<0.01); * p<05)}. [ϕ]A: Long rain season (March-May); B: Long dry season (June-September); C: Short rain season (October–November); D: Short dry season (December- February).

semen concentration, mass motility (p = 0.0014) and post freeze motility (p = 0.0009). Age of the bulls negatively affected (p=0.025) all the parameters studied, with semen collected during 2011 possessing better attributes than that collected in 2012. While the semen volume dropped with age between 2011 and 2012, from 5.16 to 5.10 ml, semen colour also lightened from a 3.28 hedonic scale score to a 3.11 score. Over the test period, semen mass motility score reduced from 2.98 to 2.65, while the proportion of live sperm in ejaculates dropped from 65 to 63% (Table 4).

DISCUSSION

Normal reproduction in male livestock is measured by the production of semen with normal and adequate spermatozoa, as well as the desired ability to mate. These sexual functions (sexual development, production of spermatozoa and desired ability to mate) are under the

Table 4. Influence of year on semen quality.

Parameter	Years		
	2011 (n = 568)	2012 (n = 823)	P-Value
Volume (ml)	5.16±0.09	5.10±0.08	
Libido Score	3.27±0.02[a]	2.95±0.01[b]	***
Semen colour (%)			*
Cream (%)	62.8	54.0	
Milky (%)	21.5	37.5	
Watery (%)	6.5	2.4	
Yellowish (%)	8.2	5.7	
Semen concentration (10^9 spz/ml)	3.28±0.04[a]	3.11±0.03[b]	***
Mass motility (%)	2.98±0.03[a]	2.65±0.03[b]	***
Individual motility (%)	65.08±0.8[a]	63.12±0.5[b]	**
Live-dead %	30.44±0.6[b]	36.76±0.5[a]	**
Post freezer motility (%)	40.50±0.8[a]	41.93±0.5[a]	*

[abcd] Values within the same column with different superscripts differed significantly { ***(p<0.001); **(p<0.01); * p<05)}.

control of gonadotrophin hormones such as testosterone, LH and FSH. These gonadotrophins are influenced to a larger extent by a combination of environmental fctors such as temperature, nutrition and animal management practices (Vilakazi and Webb, 2004). Temperature is one of the important factors affecting reproduction. Periods of high temperature damage the spermatogenic cells and lead to testicular degeneration, reduction in the efficiency of spermatogenesis and hence poor semen quality (Vilakazi and Webb, 2004). Season factors include temperature, photoperiod, humidity and feed quality (Andrabi et al., 2002; Barth and Waldner, 2002; Menon et al., 2011). Differences in the quantity of feed or in feed composition, environmental temperature, humidity and seasonal variation do affect semen output (McDowell, 1972; Castillo et al., 1987; Soderquist, 1996; Koivisto et al., 2009).

In the area where there is marked seasonal variation in environmental temperature, bull semen quality tends to be lower during summer or in tropical terms, warm months (Curtis, 1983; Vilakazi et al., 2004) as this results in thermal stress. Thermal stresses cause testicular degeneration, abdominal scrotal thermogram and hence lower the semen output (McDowell, 1972; Curtis, 1983). Significant seasonal variations are also observed in the incidence of sperm head abnormalities and total sperm abnomalities; and appear to be strongly associated with dry seasons (spring and summer) as compared to rain seasons. The results of this study indicated that a higher percentage of normal sperm occured during short rainy season and this was in agreement with Mathevon et al. (1998) where short rain (spring) season was also associated with higher percentage of normal sperm regardless of the age and breed of the bull.

In this study, age significantly affected semen characteristics. Previous studies also reported that the bulls aged 36 to 48 months were found to produce sperm of better morphology than bulls of 72 months age and older (Vilakazi and Webb, 2004). This succinctly shows the importance of bull age on influencing semen morphological traits. Several researchers have attributed similar observations to the scrotal circumference, the regulation balance mechanism, fat deposition in the brain and reproductive tissues which affect semen production and quality (McDowell, 1972; Salisbury et al., 1978; King, 1993; Coe, 1999; Mamabolo, 1999; Brito et al., 2002). Dairy bulls reach puberty at the age of 12 months (Bearden and Fuquay, 1997; Vilakazi and Webb, 2004) and attain maturity at the age of 3 to 4 years (Almquist, 1982). These studies found that bulls recorded higher sperm defects prior to maturity. This is probably due to the fact that in younger bulls, the testicles are still developing and hence the semen in the ejaculate is of low quality (Coulter and Foote, 1979; Vilakazi and Webb, 2004). Lower semen outputs in older bulls may be associated with the degenerative changes in seminiferous tubule (Coe, 1999), fat deposition which may take place in scrotum (Salisbury et al., 1978; King 1993) and the break down of body tissues, particularly, testicular tissues (King, 1993) with advancement in age. Fat deposition as a bull progresses in age may take place around the scrotum. This may affect semen quality by reducing the heat radiation capacity from the scrotal neck (Brito et al., 2002). Indeed, supportive findings by Vilakazi and Webb (2004) reported that the semen quality starts to deteriorate in bulls older than 72 months.

This deterioration may be associated with the accumulative hazards of life including non-specific infections, nutritional stress, diseases and accidents, which all combine to cause the direct positive relationship between semen quality and age to disappear (Salisbury et al., 1978; Vilakazi and Webb, 2004; Christensen et al., 2011). Its therefore very interesting for us to report that age as a factor is a necessary evil and paradoxical, in that at a young age, low age is disadvantageous and leads to poor quality semen, in mid-age, the age effect becomes positive, with bulls producing high grade/quality semen, before the bulls age effect becomes negative, causing the production of abnormal and sub-standard semen. Studies that have combined the effects of age and season have found that younger bulls recorded poor semen morphology during winter, while old bulls showed poor morphology during long dry season (Vilakazi and Webb, 2004; Koivisto et al., 2009; Ghasemi and Ghorban, 2014).

The current study hence recognizes that breed, age and season and their interactions are important sources of variation in semen quality. This implies that for a successful artificial insemination programme, semen collection should be done at the younger age, from two years to a maximum of 5 years for all breeds. It is therefore recommended that age, breed and season should be given urgent attention in any bull management system employed in Rwanda in order to obtain the best semen quality.

Indeed, when breed effects are kept out of the picture, past studies (Vilakazi and Webb, 2004) showed that the summer season is associated with very poor semen quality and is not ideal for semen collection from bulls that are five years or older. Manipulation of temperature in dairy cattle through the provision of management practices to reduce the effect of heat stress on bull reproduction is hereby suggested as a primary tool in optimising the quality of semen harvested in AI dairy bulls in Rwanda.

CONCLUSION AND RECOMMENDATIONS

In conclusion, Friesian bulls had better semen quality, the short rainy season had the best semen quality, as was the semen collected earlier. Hence, the Friesian breed should be promoted at the bull station ahead of the Jersey. Most semen should be collected during the rainy season, particularly the short rains. Particularly, bulls below three years of age should be of focus. It can be recommended that the relationship between the nutrition, reproduction physiology and management should be given a high priority in dairy production systems and further studies in this regard should be undertaken.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests.

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Vol. 8(6), pp. 79-86, June 2017
DOI: 10.5897/IJLP2016.0354
Article Number: 739648364337
ISSN 2141-2448
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http://www.academicjournals.org/IJLP

International Journal of Livestock Production

Full Length Research Paper

Fattened cattle marketing systems in Moretna Jiru District, North Shoa Zone, Amhara Regional State, Ethiopia

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Received 3 December, 2106; Accepted 21 March, 2017

The study was conducted in Moretna Jiru district, North Shoa zones of Amhara Regional State of Ethiopia from February 2014 to January 2016 to assess fattening cattle marketing system. The primary and secondary data were collected through structured interview, focus group discussion and direct filed observation. Statistical package for social science (SPSS 16) were used to analyze data. In the study area, most respondents (94.8%) did not record cattle history but 75% of respondents have recorded their cost analysis. Producers, traders and brokers were the main actors in fattened cattle marketing in the study area. Producers and brokers took the first and third rank respectively but brokers have a significant impact on bargaining. Traditionally, producers and traders invite the persons who made bargaining which is called "fintir". This was done by contributing equal amount of money from (seller and buyer). Most (45.0%) respondents bought cattle from South Wollo district market and 66.7% respondents were sold at village market. Majority of respondents in the study area obtain marketing information from market visit and neighbors. The maximum and minimum price of fattened cattle in the study area in 2015 was 58,000 and 21,000 Ethiopian birr (2566 and 927 US dollars) respectively. Majority (98.3%) of the respondents reported the occurrence of market fluctuation in fattening cattle due to different reasons. Fasting was the main cause (42.4%) for market fluctuation. Most respondents traveled on foot to buy and sell fattened cattle. The major challenge to transport fattened cattle to and from market was found to be transportation facilities. All of the producers and brokers did not have any license on fattening cattle for marketing and only 5% of trader's respondents had a license. This research was used to generate baseline information on fattened cattle market.

Key words: Infrastructure, license, market actors, marketing fluctuation, market information.

INTRODUCTION

Ethiopia has a cattle population of about 53.4 million heads and the majority (99.26%) of them are local breeds, which are found in rural areas under subsistence type of farming system (CSA, 2010/11). Despite the contribution of livestock to the economy and to smallholders' livelihood, the production system is not adequately market-oriented (Eyob and Zewudu, 2016). Livestock marketing operations are generally small-scale family businesses. The supply of livestock to the markets by producers is not based on market demand, rather the buyer chooses from whatever is available in the market. The live animals are either transported in trucks or herded over long distances to feedlot operators, export abattoirs, or major markets. The routes used lack adequate feed, water, and resting places. The final market destinations are far away from supply sources, and the inadequate transport system results in significant weight loss and even death of live animals.

In some cases repeat transactions are possible. However, there are no binding contractual arrangements among different market actors. Price is determined through bargaining at the market; livestock producers are usually less informed about price, supply, and demand situations. Suppliers (producers) are highly fragmented, while there is a concentration of major livestock buyers, a situation which might lead to noncompetitive pricing and marketing behavior (CSA, 2005).

There are several marketing channels through which cattle, sheep, and goats flow to final consumers in both the domestic and export markets. The livestock marketing channels, which start with the smallholder livestock producers from the mixed crop-livestock farming system, mainly cater to the domestic market. The marketing channel starting with the pastoralists is for both domestic and export markets. The market actors may only be involved in cattle, sheep and goats, or cattle, sheep, and goat transactions (Fekadu, 2006).

In Ethiopia, both legal and illegal marketing systems operate at different magnitudes. Most livestock sales are related to farm households, cash needs and commercial orientation. However, cattle sales are also induced by fear of theft and insecurity. The current knowledge on livestock market structure, performance and price is poor and inadequate for designing policies and institutions to overcome the problems in the marketing system. In addition, the current knowledge on marketing orientation of livestock in the study area is also poor with a lack of scientific information. Based on the above information, the current study was conducted to assess the marketing of fattened cattle in Moretna Jiru district, North Shoa zone in Ethiopia. In this area oxen, mainly used for drought power are put into feedlots for a certain period of time so as to improve their body condition. Afterwards the oxen are moved to the nearby market and sold at higher price as demonstrated by the farmers that kept oxen under traditional feedlot conditions for 1- 2 years and ultimately sold them for 45-55 thousand in Ethiopian birr (2566 and 927 US dollar). This study helps to improve the supply of quality fattened animals to the market and aims at improving the marketing systems of fattened cattle so that the buyers and sellers can directly meet.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Amhara Regional State, North Shoa zone of Moretna Jiru district over a period of 23 months (from February 2014 to January 2016). The coordinates for the study area are 39° 19' 24'' E and 10° 6' 2''N. The area located 195 km North East of Addis Abeba with an altitude ranges from 1,500 t0 2694 m above sea level and receives an annual rainfall of 850 mm while the temperature varies from 5.2°C in November to 28.8°C in June.

Sources and method of data collection

The study was conducted based on both primary and secondary data sources. Primary data was collected through face to face interviews, personal observation and informal discussion with producers, traders and brokers. The sources of secondary information were from districts and zonal agricultural and trade offices. Questionnaire survey was conducted on 90 households. The households were identified by using a systematic random sampling technique. The cattle marketing site was chosen based on the ability to provide a high supply of cattle to domestic trade and the availability of a weighing scale facility for ease of transaction. In all the markets, the market survey was carried out once a week on a major market day.

Data analysis

The qualitative and quantitative data sets were recorded and entered in to statistical package for social science (SPSS version16) computer program for analysis. Descriptive analysis was employed for data analysis. This method of data analysis refers to the use of ratios, figures, percentages, means and charts in the process of examining and describing marketing functions, facilities, services, intermediaries, and market and cattle characteristics.

RESULT AND DISCUSSION

Socio economic characteristics of respondent

The average family size of the respondents was about 5.8±0.3 but the range was quite broad and spanned between 2 to 14 per household. This result is similar to the average family size reported by Abdi et al. (2013). The majority (97.5%) of the respondents was male and the average age of the respondents was 43.8 years. The maximum and minimum age of the respondents was 69 and 21 years respectively (Table 1); this result is also

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Table 1. Socio economic characteristics of respondent.

District	Socio economic characteristics of respondent					
	Sex (%)		Occupation (%)		Age (mean)	Family size (mean)
Moretna Jiru	Male	Female	Farmer	Merchant		
	96.7	3.3	98.3	1.7	43.83±1.5	5.8±0.3

Table 2. Fattening animal and financial recording practice.

Activities	Response (n=90)	
	Yes (%)	No (%)
Animal records	5.2	94.8
Financial records*	75.0	25.0
Is there any nearby market to buy and sell cattle	100	0
Is there any marketing fluctuation	98.3	1.7

*= any costs spend to fatten cattle.

Table 3. Accessibility of market and the place for fattening cattle.

Activities (%)	Response (n=90)	n (%)
Where fattened cattle was bought	Menz Districts	35.0
	South Wollo Districts	45.0
	Siyadebrna Wayu	6.7
	Village Market	13.3
Where fattened cattle was sold	Village Market	66.7
	Addis Ababa Market	15.0
	Debre Berhan Market	8.3
	Siyadebrna Wayu Market	10.0

similar with the report by Umar et al. (2008). Farmers comprised of 98.3% of respondents (Table 1).

Financial and animal recording practice

In the study area, most respondents (94.8%) did not have records of cattle history during fattening period. The health status, body condition, cattle breed and other cattle information were not recorded before and after fattening. The result also revealed that most respondents (75%) have financial records but the financial record did not include the cost of labor and crop residues. According to the respondents, there was a nearby market to sell and buy fattened cattle though the price was fluctuating (Table 2).

Place of market to buy and sell fattened cattle

Most respondents (45.0%) bought cattle for fattening from south Wollo districts followed by Menz districts (35.0%) but majority of respondents (66.7%) sold fattened cattle at the village market. This is due better price and relatively short distance market. 15% of respondents sold fattened cattle in Addis Ababa. According to focus group discussions, most participants (75%) travelled more than 30 kilometers on foot to buy fattened cattle (Table 3).

Time of fattened cattle offered to market

Most respondents (45.9%) offered fattened cattle to market by considering rate of weight change and the increase in the price of fattened cattle during the months of April-May (due to Eastern holiday). The price decreases from July to August since livestock producers mostly focus on crop production. The maximum and minimum price of fattened cattle in the study area in 2015 was 2566 and 927 US dollars (Table 4). This result was higher than the result reported by (Shewangizaw, 2016)

Table 4. Time of fattened cattle sold.

Activities (%)	Response (n=90)	n (%)
When did you sale your fattened cattle	Calculating feeding length	11.2
	Considering rate of weight change	45.9
	Anticipated current and future price	28.8
	Feeding length and live weight change	12.8
When did the price increase	April-May (Eastern)	98.1
	Jun-August	1.9
	September- End of January (Chris mass)	0
When did the price decrease	February- May	7.7
	September –January	11.5
	July- August	80.8
Price of fattened cattle	Maximum price of fattened cattle (Ethiopian birr)	58000
	Minimum price of fattened cattle (Ethiopian birr)	21000
	Average price of fattened cattle (Ethiopian birr)	39500

1 US dollar =22.65 Ethiopian birr but fluctuated.

Table 5. Alternatives of marketing to sell the fattened cattle.

Districts		Where you sold and bought fattened cattle (N=90)				
		Regular market	Directly to stockers	Directly to feedlot	Cash contract	Special selling
Moretna Jiru	Regularly	69	31.9	40.4	34	0
	Occasionally	31	55.3	46.8	46.8	39.1
	Never	0	12.8	12.8	19.2	60.9

N= number of respondents.

who reported the maximum and minimum price of fattened cattle in the dry and wet season as 20,000 and 10000, and 13000 and 8000 Ethiopian birr, respectively and Shitahun (2009) also reported the mean price of cattle before and after fattening was about 965 birr and 1505 birr, respectively.

Marketing alternatives of fattened cattle

Markets and marketing system of fattened cattle are the dominant sources of risk in the production units of farmers (insert reference to qualify this statement). Most respondents (69%) in Moretna Jiru sold and bought fattened cattle at the regular market (Table 5). Comparable result was reported by Mlote et al. (2013) who reported about 58.7% of the fattened beef cattle were sold at Pugu Secondary Market in Dares Salaam.

Major actors in fattening cattle marketing system

Producers, traders and brokers were the main actors in fattened cattle marketing systems. Producers were ranked first followed by traders even if brokers have significant role in connecting both the buyers and sellers via bargaining (Figure 1). This result was in agreement to Shewangizaw et al. (2014). According to the focus group discussions, the price of fattened cattle was determined by the bargaining of producers and traders but traders take the first rank. The marketing root passes producer, trader, butcher and consumer respectively. These long marketing roots influence producer’s interms of fattened cattle price. Therefore, farmers require best alternatives to minimize and avoid this unprofitable transaction in the chain and ensure fair and legitimate marketing system (Tsegay and Mengistu, 2013). Variations in type of markets and customers also influence profit gain from fattened cattle (Habtamu, 2012).

Source of market information in the study areas

Fattened cattle producers obtain different market information from market visit, neighbors, extension agents, cooperatives, traders and brokers. According to

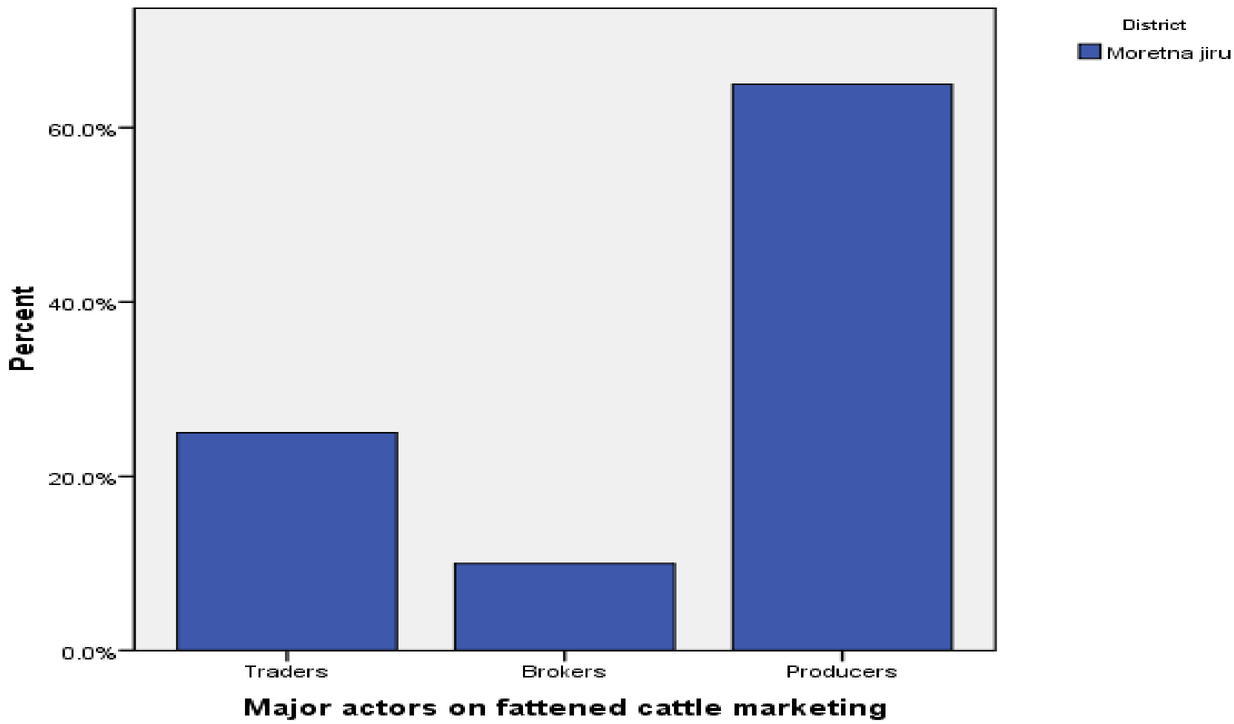

Figure 1. Major actors in fattened cattle marketing system.

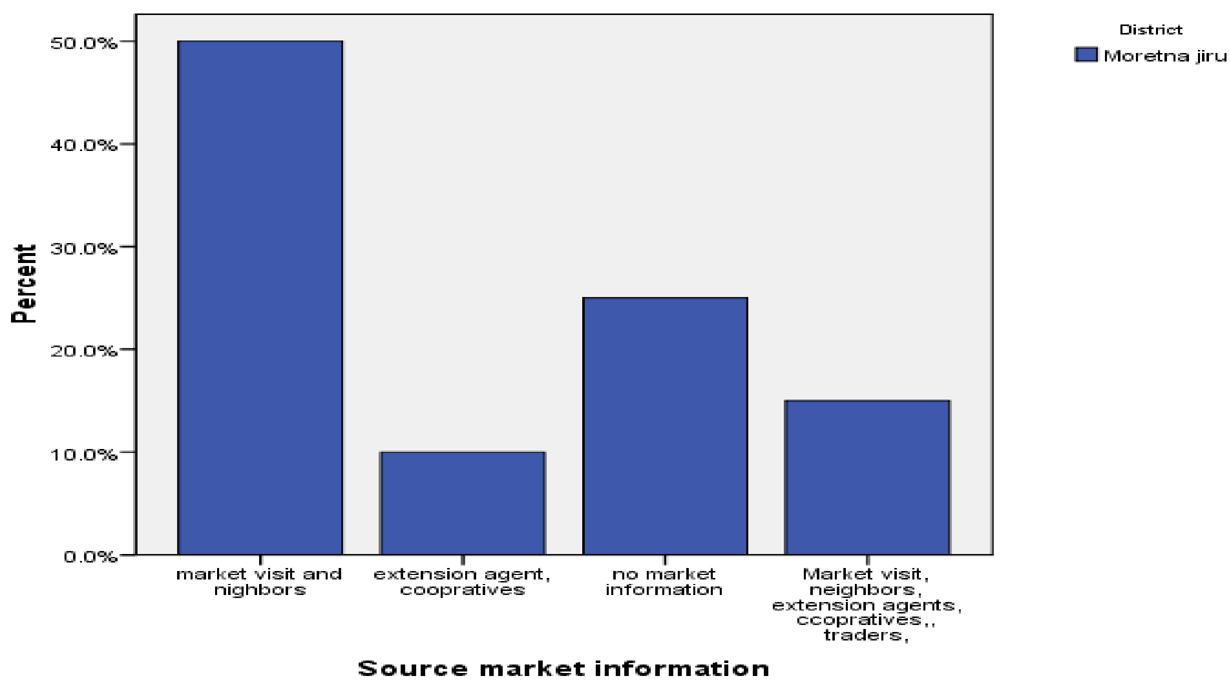

Figure 2. Sources of market information.

the result reported in Figure 2, majority of respondents in the study area get marketing information from market visit and neighbors. In livestock marketing system, information is held as a private property and not equally shared among the different participants in the value chain and usually lacks trickledown effect.

Figure 3. Fattened cattle at Enewary market (Moretna Jiru district).

Table 6. Marketing fluctuation.

Marketing activities (%)	Response (n=90)	n (%)
Fluctuation in (%)	Yes	98.3
	No	1.7
Reasons (%)	Fasting	42.4
	Season	1.7
	Both season and fasting	55.9

Marketing fluctuation

Most respondents (98.3%) reported that there was market fluctuation due to season and fasting (55.9%), fasting (42.4%), and season (1.7&) respectively (Table 6). Marketing fluctuation on fattened cattle marketing is due to different reasons. Season and fasting were the main important factors for market fluctuation (55.9%). Fasting took the first rank for fluctuation of market on fattened cattle (42.4%). The same result was reported by Shewangizaw (2016). According to focus group discussion, respondents reported that the sex and age of fattened cattle also determines the price of fattened cattle. Comparable result was reported by Mlote et al. (2013), Shitahun (2009) and Teshager et al. (2013) who reported the price of cattle differed according to sex, body conformation and age of fattened cattle.

Purpose of cattle fattening and selling

The result of this study revealed that cattle were kept for different purpose. Purchase of grain, health care expenditure, buying cloths, replacement of cattle, and purchase of cattle feed, purchase of fertilizer and purchase of other food resources were the main reasons for selling fattened cattle (Table 7). The present study is similar to Teshager et al. (2013) who reported similar reasons for selling fattened cattle.

Transportation of fattened cattle

Transportation facilities are also reported to be poor and infrequent, which could further limit the number of a farmer's market outlets. The respondents reported that fattened cattle transportation infrastructure were very inconvenient. According to the respondents report, most fattened cattle travel on foot to and from cattle market. Comparable result was reported by Eyob and Zewudu (2016). As the result revealed in Table 8, some (23.3%) respondents used vehicle to transport fattened cattle. Therefore, the transportation of fattened cattle from market to producers' house and from market to the slaughter house was on foot.

Marketing place/area

In the study area, fattened cattle marking took place in an open area (Figure 3). The marketing place did not have any shade and fence but it has a boundary between other livestock. The boundary did not have any fence and mark.

Table 7. Reasons of cattle fattening and selling.

Districts		Reasons of fattening and selling (%)		
		Very important	Important	Less important
Moretna Jiru	Purchase of grain	3.2	22.2	74.1
	Purchase of other food	7.4	20.4	72.2
	Health care expenditure	3.4	41.4	55.2
	Buying cloths	0	48.3	51.7
	Replacement of cattle	54.2	44.1	1.7
	Purchase of cattle feed	6.8	50.8	42.4
	Purchase of fertilizer	50.9	45.6	3.5

Table 8. Transportation of fattening cattle to and from market.

Transportation system	Response (%) (n=90)
Vehicle	23.3
On foot	63.3
Both	13.3

Table 9. Licensing of fattening cattle market.

Do you have a license	Response (%), N=90	n (%)
Fattener (producer)	Yes	0
	No	100
Trader	Yes	5
	No	95
Broker	Yes	0
	No	100

N=Number of respondents in percentage.

Even though the area has not fences those livestock species have not mixed together in the study area. Incomparable result was reported by Shitahun (2009) who reported marketing of fattening cattle and other cattle took place at the same open area by mixing together.

Licensing

All producers did not have any license to buy and sell fattened cattle but a few (5%) traders had a license. In the study area, all brokers did not have any license to negotiate buyers and sellers but they have a deceive role on fattened cattle marketing systems (Table 9). The same result was reported by Habtamu (2012) who reported no farmer had a license to export cattle, but 550 cattle were exported directly by farmers themselves.

CONCLUSION AND RECOMMENDATION

The results of the study concluded that marketing of fattening cattle in the study area was fluctuated due to different reasons. All most all marketing actors did not have license to buy and sell fattened cattle. Cattle marketing and market related things are a crucial problem. Producers do not benefit from their fattened cattle because of lack of fair selling price, broker interference and also lack of fencing at the market place in the studied area. So promotion of livestock marketing study will solve the problem and bringing all actors along value chain will improve the market access for optimum benefit of each actors. Establishing cattle market information center plays a vital role in getting the current market price. On the other hand, the fatteners should be able to have an open access to micro finance institution that empowers them having credit system. The government should put the marketing guidelines on fattened cattle with the current scientific knowledge in order to enhance the sector for its contribution to household income generation activities.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Vol. 8(6), pp. 87-94, June 2017
DOI: 10.5897/IJLP2016.0343
Article Number: BB83C5A64339
ISSN 2141-2448
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International Journal of Livestock Production

Full Length Research Paper

Bodyweight gain and carcass characteristics of Horro sheep fed urea treated maize husk and untreated maize husk supplemented with different levels of concentrate mix at Bako, Western Ethiopia

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Received 30 October, 2016; Accepted 10 April, 2017

The experiment was conducted for 90 days of feeding trial at Bako district, Western Ethiopia using twenty yearling male Horro sheep weighing 20.42 ± 0.35 kg (mean ± SD) with the objectives to evaluate the effect of supplementation of nougseed meal and wheat bran mix (1:1) on body weight (BW) gain and carcass characteristics of Horro sheep. The experiment was arranged with four blocks and four treatments in a randomized complete block design. The treatments were *ad libitum* feeding of urea treated maize husk (UTMH, T1) and untreated maize husk (UMH) supplemented with 200 g (T2), 300 g (T3) and 400 g (T4) of nougseed meal (NSM) and wheat bran (WB) mix (1:1) on the dry matter (DM) basis. Supplementation decreased (P<0.001) UMH DM intake as compared to intake of sole UTMH. Daily BW gain, final BW, empty BW, hot carcass weight and dressing percent (DP) were higher (P<0.001) in supplemented treatments. Sheep fed on the high level of supplementation (T4) had significantly heavier (P<0.001) rib eye muscle area and more muscle deposition. It was concluded that supplementation of Horro sheep with different levels of NSM and WB mix promoted BW gain, (DP) and increased the proportion of edible offal. Increasing trend of BW gain between the different levels of supplementation during the trial used in this study is an indication of the use of additional level than the high (T4) level of supplementation to obtain more BW gain in Horro sheep.

Key words: Body weight, carcass characteristics, concentrate mix, Horro sheep, maize husk.

INTRODUCTION

In subsistence agriculture, which is common in developing countries like Ethiopia, farmers keep small ruminants for sale and household meat consumption where gross income is determined by the flock number raised by the

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owners (Gemeda et al., 2007; Temesgen et al., 2007). In fact, under Ethiopian condition, the aim of sheep producers is to get their lambs to slaughter weight in a short period of time with the maximum amount of lean meat, minimum bone and an amount of fat, which is desired by the consumers (Aschalew and Getachew, 2013). However, FAO (1997) reported that mean carcass weight of sheep is less than 10 kg per animal, which is the second lowest in sub-Saharan African. Gemeda et al. (2007) and Tesfa et al. (2013) suggested that, among many factors, plane of nutrition plays a major role in contributing to the variation in growth performance (carcass weight) and carcass compositions in sheep. Temesgen et al. (2007) noted that sheep productivity was based on large flock number, which is not viable option due to growing human population. Instead, intensified feeding may be one way to raise production per unit of animal in a sustainable way on the basis of available feed resource utilization as suggested by Shapiro et al. (2004).

Diriba and Lemma (2001) reported that maize is the major cereal crop in the western Ethiopia, particularly in the study area and its area of production is increasing from time to time more than other crops. As a result, the contribution of maize residues to animal feed resource is also increasing, particularly in early months of the dry season (Diriba et al., 2001; Thorne et al., 2002).

Maize husk is part of maize residue which is less digestible and low in available nutrients such as crude protein (CP) and digestible energy and slow rate of microbial fermentation (Adebowale, 1988; Ranjhan, 1997). These characteristics limit its intake and digestibility thereby hampering the productivity of farm animals (Nguyen, 1998; Undi et al., 2001). But, there are technical possibilities of upgrading the nutritive value of this residue by means of chemical treatment and/or proper supplementation of concentrates.

The objective of this study was to evaluate the effect of urea treatment and supplementation of different levels of concentrate mix on body weight gain and carcass characteristics of Horro sheep fed on maize husk.

MATERIALS AND METHODS

Study area

The experiment was conducted at Bako District, Western Ethiopia, which is located at an altitude of 1650 m above sea level, and at 09° 06' 56" N latitude and 37° 03' 30" E longitude at about 239 km from Addis Ababa. The mean annual rainfall is 1242 mm, and the mean annual maximum and minimum temperatures ranges (13.3-27.9°C) during the period of 1961 to 2010 (Meteorological Station; Bako Agricultural Research Center).

Experimental design and feeding management

Twenty yearling male Horro sheep with initial body weight (BW) of 20.42 ± 0.35 kg (mean ± SD) and housed in individual pens were used in a randomized complete block design. The experimental sheep were grouped into four blocks with similar BW and one from each block was assigned at random to a treatment feed. The treatments consisted of *ad libitum* feeding of chopped cured urea treated maize husk (UTMH) (T1), *ad libitum* feeding of chopped cured untreated maize husk (UMH) and daily supplementation with 200 (T2), 300 (T3) and 400 g (T4) nougseed meal (NSM) and WB mix at 1:1 ratio. The supplements were offered in two equal parts at 8:00 and 16:00 h daily, and the experimental sheep had free access to mineral salt and water. Feed intake was recorded daily for the 90 days of feeding trial and BW was measured at ten days' interval after overnight fasting. The cured UMH contained 93.56% organic matter (OM), 5.76% crude protein (CP), 75.8% neutral detergent fiber (NDF) and the NSM-WB mixture contained 94.61% OM, 24.13% CP and 41.1% NDF.

Determination of carcass components

At the termination of 90 days feeding trial, all sheep were fasted overnight, weighed and slaughtered. Different components of the carcass were separated, weighed and recorded for each sheep. The rib eye muscle area was traced between the twelfth and thirtieth rib and the area was measured with traced square paper. Empty BW was calculated as slaughter weight less gut content. Dressing percent was calculated as proportion of hot carcass weight to slaughter weight and/or empty BW. Percent of total edibleoffal (TEO) was calculated as the sum of blood, lung, trachea, heart, liver, spleen, empty gut, kidney and internal fat (mesenteric and kidney) weight to slaughter weight. Also percent of total non-edible offal (TNEO) was calculated as the sum of head, skin, genital organs, gall bladder and gut fill weight to slaughter weight.

Data analysis

Experimental data were subjected to the analysis of variance using the computer software SAS. Treatment means were separated by least significant difference test (LSD). The model for a randomized complete block design below was used for assessing the experimental data.

$$Y_{ij} = \mu + T_i + B_i + E_{ij},$$

where Y_{ij} = the response variable, μ = overall mean, T_i = treatment effect, B_j = block effect, and E_{ij} = random error.

RESULTS AND DISCUSSION

Digestible nutrient intake

Within the supplemented group of sheep, all total digestible nutrient intake increased (P<0.001) with the level of supplement offered (Table 1). Similarly, Mulugeta and Gebrehiwot (2013) reported that the nutrient intake increases with the increase of level of supplementation with Sesame cake to sheep fed on wheat bran and teff straw. The digestible nutrient intake of UTMH (T1) is lower (P<0.001) compared to supplemented group. The digestible CP intake for T1 and T2 was similar (P<0.001) as the later offered lower amount of supplement which indicates potential of small amount of urea to provide CP for ruminants when added to poor quality roughages.

Table 1. Digestible nutrient intake of Horro sheep fed urea treated maize husk and untreated maize husk supplemented with different levels of wheat bran and nougseed meal mix.

Parameter	Digestible Nutrient intake (g/kg DM)				SEM	SL
	T1	T2	T3	T4		
DM	391.1[d]	517.2[c]	567.4[b]	652.2[a]	9.386	***
OM	375.6[d]	493.8[c]	543.0[b]	623.5[a]	8.575	***
CP	55.8[c]	58.1[c]	75.8[b]	95.8[a]	1.612	***
NDF	274.4[d]	363.6[c]	382.0[b]	436.1[a]	6.585	***
ADF	133.5[d]	212.3[c]	228.4[b]	272.3[a]	4.341	***

[a,b,c,d]Means with the same letter in the same row are not significantly different, ***P<0.001; ADF: Acid detergent fiber; CP: crude protein; DM: dry matter; NDF: neutral detergent fiber; OM: organic matter; SEM: standard error mean, SL: significance level.

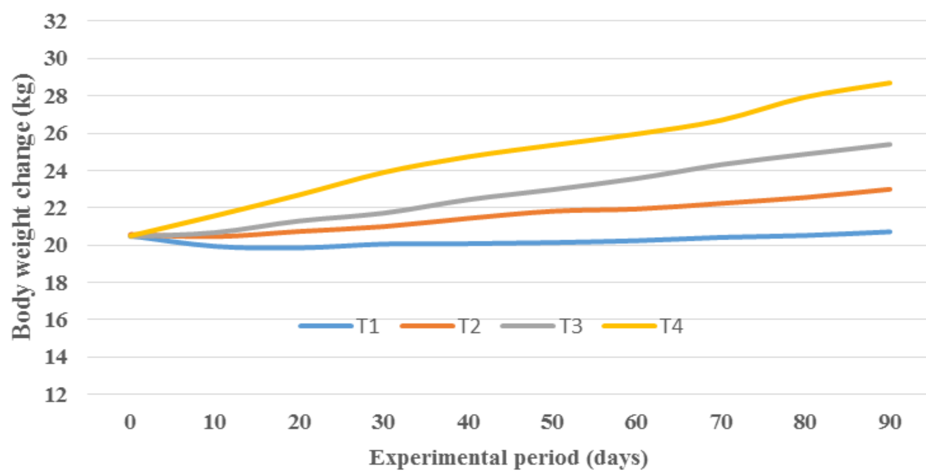

Figure 1. Trends in body weight gain of Horro sheep fed sole urea treated maize husk and untreated maize husk supplemented with different levels of wheat bran and nougseed meal mix. T1: UTMH; T2: UMH + 200 g (WB + NSM); T3: UMH + 300 g (WB + NSM); T4: UMH + 400 g (WB + NSM).

Improved intake of urea treated cereal straw in sheep has been reported by other study (Getahun, 2013).

Body weight change and feed conversion efficiency

Differences (P<0.001) were observed in daily BW gain and final BW among the supplemented sheep. Positive correlation (P<0.001; r = 0.792) between CP intake and mean daily BW gain (Figure 2) was observed. Treatment diets resulted in a higher variation (P<0.001) in BW change and ADG. Sheep supplemented with concentrate feeds had higher (P<0.001) ADG as compared to those fed sole UTMH (T1). The maximum ADG of sheep was achieved by offering UMH with 400 g concentrate mix. Similar results were reported by Aschalew and Getachew (2013), Mulugeta and Gebrehiwot (2013), and Sultana et al. (2012). Based on this result, it can be concluded that supplementation can improve ADG at all levels used in the present experiment, perhaps through providing nutrients available for absorption or by enhancing microbial protein synthesis (Figure 1). This result is supported by Awet and Solomon (2009) and Zemicael and Solomon (2009) and Tesfa et al. (2013) that showed supplement rations improve BW gain, where different supplements have no equal potentials to supply nutrients for growth.

During the whole experimental period, the animals fed on UTMH maintained their BW. Similar results were obtained by Adugna and Frik (2000), in which supplementation of graded levels of *Desmodium intortum* hay to sheep fed on maize residue harvested at different stages of growth resulted in significant BW gain with increasing level of supplementation. The current lower BW gain in sheep fed sole UTMH despite its optimum CP content might be due to its high fiber content and the loss of volatile nutrients and ammonia from UTMH throughout the daytime that might have decreased the CP content

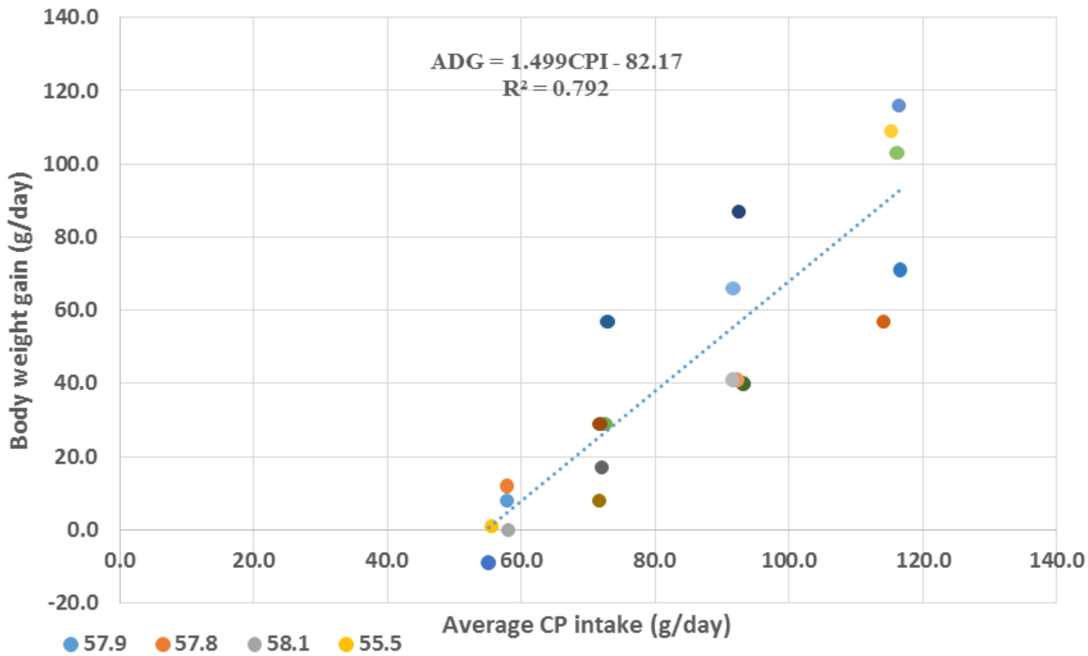

Figure 2. Regression of mean daily body weight gain on mean daily crude protein intake in Horro sheep fed sole urea treated maize husk and untreated maize husk supplemented with different levels of wheat bran and nougseed meal mix. ADG: Average daily gain, CPI: crude protein intake, R: regression.

Table 2. Body weight change and feed conversion efficiency of Horro sheep fed sole urea treated maize husk and untreated maize husk supplemented with different levels of nougseed meal and wheat bran mix.

Parameter	T1	T2	T3	T4	SEM	SL
IBW (kg)	20.50	20.48	20.52	20.50	0.05	ns
FBW (kg)	20.7[d]	23.1[c]	25.4[b]	28.7[a]	0.79	***
BWC (kg)	0.22[d]	2.5[c]	4.9[b]	8.2[a]	0.80	***
ADG (g/day)	2.44[d]	27.8[c]	54.9[b]	91.1[a]	8.94	***
DMI (g/day)	545.24[d]	671.1[c]	729.3[b]	846.5[a]	9.29	***
FCE	0.0044[c]	0.041[b]	0.075[a]	0.108[a]	0.01	***

[a,b,c,d]Means with the same letter in the same row are not significantly different, ***P<0.001; ns: Non-significant; ADG: average daily gain; BWC: body weight change; DMI: dry matter intake; FBW: final body weight; FCE: feed conversion efficiency; IBW: initial body weight; SEM: standard error mean

to be less than 10.42% obtained in chemical analysis. Supplementation of concentrate mix increases growth rate of Bengal goats (Sultana et al., 2014) which corresponds to the present results.

Based on the present study, the optimum level of concentrate mix supplementation to UMH in terms of sheep BW gain per kg DMI was 400 g, in which maximum BW gain, better FCE and optimum net return was obtained. In the present study, the doubling of ADG with increasing level of supplementation needs attention and may show the potential feedlot performance of this breed (Table 2).

Feed conversion efficiency was higher (P<0.001) for treatments in the order T4=T3>T2>T1. The low FCE for UTMH (T1) was probably because of the lower CP and energy intake and higher fiber content of the diet that might have caused the use of net efficiency of metabolisable energy to be depressed significantly. The higher FCE with 400 g concentrate mix supplementation to UMH basal diet explained the nutritional advantage of concentrate mixes in providing absorbed nutrients by enhancing the maize husk nutrient utilization. In agreement with this result, Aschalew and Getachew 2013) and Mulu et al. (2008) reported improvement in FCE proportional to the levels of supplementation in sheep fed natural grass hay supplemented with treated grass pea and brewers' dried grain, respectively.

Abebe et al. (2009) also stated that improved feed

Table 3. Carcass parameters of Horro sheep fed urea treated maize husk and untreated maize husk supplemented with different levels of nougseed meal and wheat bran mix.

Parameter	T1	T2	T3	T4	SEM	SL
SW (kg)	20.64^d	23.02^c	25.36^b	28.68^a	0.80	***
EBW (kg)	18.41^d	20.3^c	22.88^b	25.2^a	0.46	***
HCW (kg)	7.38^d	9.39^c	11.52^b	13.23^a	0.57	***
Dressing % on						
SW	35.8^c	40.6^b	45.4^a	45.8^a	0.015	***
EBW	40.0^c	46.2^b	50.2^{ab}	52.4^a	0.021	***
REMA (cm^2)	5.92^d	8.97^c	11.04^b	14.7^a	0.78	***

[a,b,c,d]Means with the same letter in the same row are not significantly different, ***P<0.001, EBW: empty body weight; HCW: hot carcass weight; REMA: rib-eye muscle area; SEM: standard error mean; SL: significance level; SW: slaughter weight.

conversion ratio was observed when Arsi-Bale sheep fed hay supplemented with wheat bran, linseed meal and their mixes.

Carcass characteristics

Evaluation and making a comparison of carcass yield and characteristics for animals under fattening program is a primary importance. Supplemented sheep had higher (P<0.001) values of slaughter weight (SW), empty body weight (EBW), hot carcass weight (HCW), dressing percentage (DP) and rib eye muscle area (REMA) than sheep fed sole UTMH (Table 3). Comparison between the supplemented group showed that SW, EBW and HCW increased (P<0.001) with increasing level of concentrate mix supplementation. In agreement with the current study, both Michael and Yayneshet (2014) and Gemeda et al. (2007) reported higher carcass parameters obtained for treatments under the highest level of feeding (250 and 400 g/day concentrate mix) of Tigray highland and Horro sheep compared to those treated under lower feeding levels, respectively.

Hot carcass weight comprises of bone and flesh excluding offal whether edible or non-edible. Sheep supplementedwith the highest (T4) level of concentrate mix resulted in a higher (P<0.001) HCW due to relatively more muscle development than others. Similarly, Tesfaye (2008) and Michael and Yayneshet (2014) reported that higher HCW for high level concentrate mix supplemented Arsi-Bale sheep fed urea treated maize cob.

Dressing percentage was higher (P<0.001) in T4 and T3 as compared to T2 for supplemented group. Comparison of DP as a proportion of EBW indicated that about 4% higher for each treatment than the DP as proportion of SW for each treatment, which can be attributed to the removal of the gut content (Table 3). Payne (1990) reported that there is improvement in DP as the proportion of concentrate in the diet increased, which is in agreement with the current study. T4 resulted in higher (P<0.001) DP which is in agreement with other indigenous Ethiopian sheep DP as SW at higher level of supplementation. Similarly, the result recorded on DP in the current experiment is consistent with the report of Ulfina et al. (1999) where concentrate feeding to aged Horro ewes improved carcass quality and DP.

The rib eye muscle area (REMA) was higher (P<0.001) in the order of T4> T3> T2 > T1 (Table 3). This indicates supplemented sheep were able to develop better muscle than T1. Comparable to the current study, Abebe (2008) reported REMA of 12.85 to 15.21 cm^2 for Washera sheep fed on natural grass hay and supplemented with graded levels NSM, WB and brewery dried grain mix. Contrary to the present study, smaller REMA of 3.15 to 6.95 cm^2 and 7.0 to 8.4 cm^2 were reported by Abebe et al. (2009) in Arsi-Bale sheep at different levels of supplementation. The differences may be attributed to environmental factors, plane of nutrition and breed differences.

Edible offal

Offal components are edible or non-edible based on tradition, religion, culture and differences in norms and preferences of the people and is more or less subjective. Blood, testis, omental and mesenteric fat, tail, kidney fat and total edible offal components (P<0.001), tongue, empty gut and liver (P<0.01) and kidney (P<0.05) were higher in T4 compared to others. Lower (P< 0.001) total edible offal (TEO) was recorded in T1 and higher in T4 (Table 4). In agreement with the work of Tesfaye (2008) and Hirut (2008), supplemented sheep had higher weight of TEO compared to those fed on sole UTMH. This indicated improvement in TEO due to supplementation for sheep fed UMH basal diet. Smith (1984) and Michael and Yayneshet (2014) indicated that lamb carcass fatness is closely associated with BW and differences in their energy or dietary protein level intake when lambs

Table 4. Edible offal of Horro sheep fed sole urea treated maize husk and untreated maize husk supplemented with different levels of wheat bran and nougseed meal mix.

Parameter	T1	T2	T3	T4	SEM	SL
Blood (g/head)	783.8[d]	935.6[c]	1070.4[b]	1262.0[a]	60.21	***
Tongue (g/head)	62.4[c]	77.6[b]	80.6[b]	98.2[a]	6.79	**
Testis (g)	107.2[c]	168.2[b]	181.4[b]	287.6[a]	21.35	***
OMF (g/head)	17.0[c]	35.2[b]	79.8[a]	85.8[a]	8.25	***
EG (g/head)	1466.2[c]	1557.8[bc]	1687.6[ab]	1741.2[a]	63.30	**
Heart (g/head)	101.2	107.4	111.6	121.8	8.83	Ns
Liver (g/head)	317.4[b]	342.2[b]	333.8[b]	413.0[a]	19.09	**
Kidney (g/head)	69.8[b]	67.8[b]	74.0[ab]	89.6[a]	7.26	*
Tail (g/head)	136.4[c]	296.8[b]	344.6[b]	765.6[a]	70.27	***
KF (g/head)	15.6[c]	25.4[b]	29.6[ab]	34.6[a]	2.63	***
TEO (g/head)	3077.0[c]	3614.0[b]	3993.4[b]	4899.4[a]	175.82	***

[a,b,c,d]Means with the same letter in the same row are not significantly different; ***P<0.001; **P<0.01; *P<0.05; ns: non-significant; EG: empty gut; KF: kidney fat; OMF: omental and mesteric fat; SEM: standard error mean; SL: significance level; TEO: total edible offal.

Table 5. Non-edible offal of Horro sheep fed sole urea treated maize husk and untreated maize husk supplemented with different levels of wheat bran and nougseed meal mix.

Parameter	T1	T2	T3	T4	SEM	SL
GF (g/head)	2540.0[c]	2920.0[bc]	3118.0[b]	3780.0[a]	220.39	***
HWOT (g/head)	1114.8[b]	1121.0[b]	1213.8[a]	1288.8[a]	36.43	**
Skin (g/head)	1399.4[d]	1555.0[c]	1744.8[b]	1938.6[a]	63.13	***
Feet (g/head)	441.8[b]	477.0[ab]	460.6[b]	544.4[a]	31.31	**
Penis (g/head)	32.0[b]	45.6[a]	45.8[a]	48.4[a]	2.65	**
LTE (g/head)	346.0[c]	374.2[b]	385.0[ab]	405.2[a]	10.52	**
GB (g/head)	4.1	3.7	2.8	3.9	0.69	Ns
Spleen (g/head)	37.6[b]	53.0[ab]	49.6[ab]	61.4[a]	7.29	**
UB (g/head)	24.6	24.2	25.4	31.0	3.55	Ns
TNEO (g/head)	5940.3[c]	6573.7[bc]	7045.8[b]	8103.7[a]	298.03	***

[a,b,c,d]Means with the same letter in the same row are not significantly different, ***P<0.001; **P<0.01; ns: non-significant; GB: gall bladder; GF: gut fill; HWOT: head without tongue; LTE: lung, trachea and esophagus; SEM: standard error mean; SL: significance level; TNEO: total non-edible offal; UB: urinary bladder.

are compared at same live weight.

Non-edible offal

Gut fill, skin and TNEO were higher (P<0.001) for T4 compared to other treatments. Head without tongue, feet, penis, spleen and (lung, trachea and esophagus) were higher (P<0.01) for T3 and T4 compared to T1 and T2 (Table 5). Total non-edible offal was higher (P<0.001) insupplemented sheep than sheep fed on sole UTMH. Mulu et al. (2008) and Abebe et al. (2009) also reported heavier TNEO for supplemented Wegera and Arsi-Bale sheep, respectively than the non-supplemented sheep fed basal diet of grass hay. In contrast to the present finding, Hirut (2008) and Michael and Yayneshet (2014) reported negative effect of level of supplementation on the percentage of TNEO in Hararghe and Tigray highland sheep, respectively. The difference might be attributed to breed, geographical location and type of feed offered.

Partial budget analysis

Sheep fed sole UTMH had a negative net return (-30.21 ETB/sheep) and it was the lowest among the treatments. The net return from the supplemented treatments was -7.07, -2.13 and 50.03 ETB/head for T2, T3 and T4, respectively (Table 6). Also T2 and T3 resulted in a negative and lower net return as compared to T4. This might be due to lower amount of concentrate supplementation to T2 and T3 that resulted in statistically

Table 6. Partial budget analysis of Horro sheep fed sole urea treated maize husk and untreated maize husk supplemented with different levels of wheat bran and nougseed meal mixture.

Cost items and variables	Treatments			
	T1	T2	T3	T4
Sheep purchasing price (ETB/head)	217.00	217.00	217.00	217.00
Total basal diet intake (kg/head)	49.66	44.35	41.83	43.54
Total concentrate intake (kg/head)	0.00	18.00	27.00	36.00
Feed cost				
Cost for concentrate (ETB/head)	0.00	28.80	43.20	57.60
Cost for UTMH (ETB/head)	21.41	0.00	0.00	0.00
Cost for UMH (ETB/head)	0.00	17.97	16.91	17.57
Cost for mineral blocks (ETB/head)	2.40	2.40	2.40	2.40
Cost for labor (ETB/head)	25.40	25.40	25.40	25.40
Total variable cost (ETB/head)	49.21	74.57	87.91	102.97
Gross income (ETB/head)	236.00	284.50	302.78	370.00
Total return (ETB/head)	19.00	67.50	85.78	153.00
Net return (ETB/head)	-30.21	-7.07	-2.13	50.03
ΔNR	-	48.50	66.78	134.00
Δ TVC	-	25.36	38.70	53.76
Δ NI	-	23.14	28.08	80.24
MRR	-	0.91	0.73	1.49
MRR (%)	-	91.25	72.56	149.26

ETB: Ethiopian Birr; MRR: marginal rate of return; ΔNI: change in net income; ΔTR: change in total return; ΔTVC: change in total variable cost; T2: (UTMH alone); T3: UTMH+200 g (50%WB+50%NSM); T4: UTMH+300 g (50% WB: 50% NSM); T5: UTMH+400 g (50%WB: 50% NSM).

lower BW gain as a result of lower nutrient intake. The marginal rate of return indicated that each additional unit of 1 ETB per sheep cost increment resulted in 1 ETB and additional 0.91, 0.73 and 1.49 ETB benefit for T2, T3 and T4, respectively. Therefore, among the supplemented treatments, T4 was found to be more profitable considering the net return and marginal rate of return, because sheep which had a better nutrient intake had higher average daily weight gain which results in a higher sale price.

Conclusion

Based on result of the present study, it is suggested that supplementations of Horro sheep with concentrate mix had a positive effect on feed intake, BW gain and carcass parameters. The positive response was more pronounced for sheep supplemented with highest level of concentrate mix with UMH basal diet. Moreover, the result of partial budget analysis (Table 6) indicated that the highest level of concentrate mix supplementation returned the highest profit than the other levels of supplementations. Therefore, supplementation of UMH with 400 g concentrate mix is biologically more efficient than the low level of supplementation and potentially more profitable, which tends to be economically recommended for feedlot fattening of Horro sheep.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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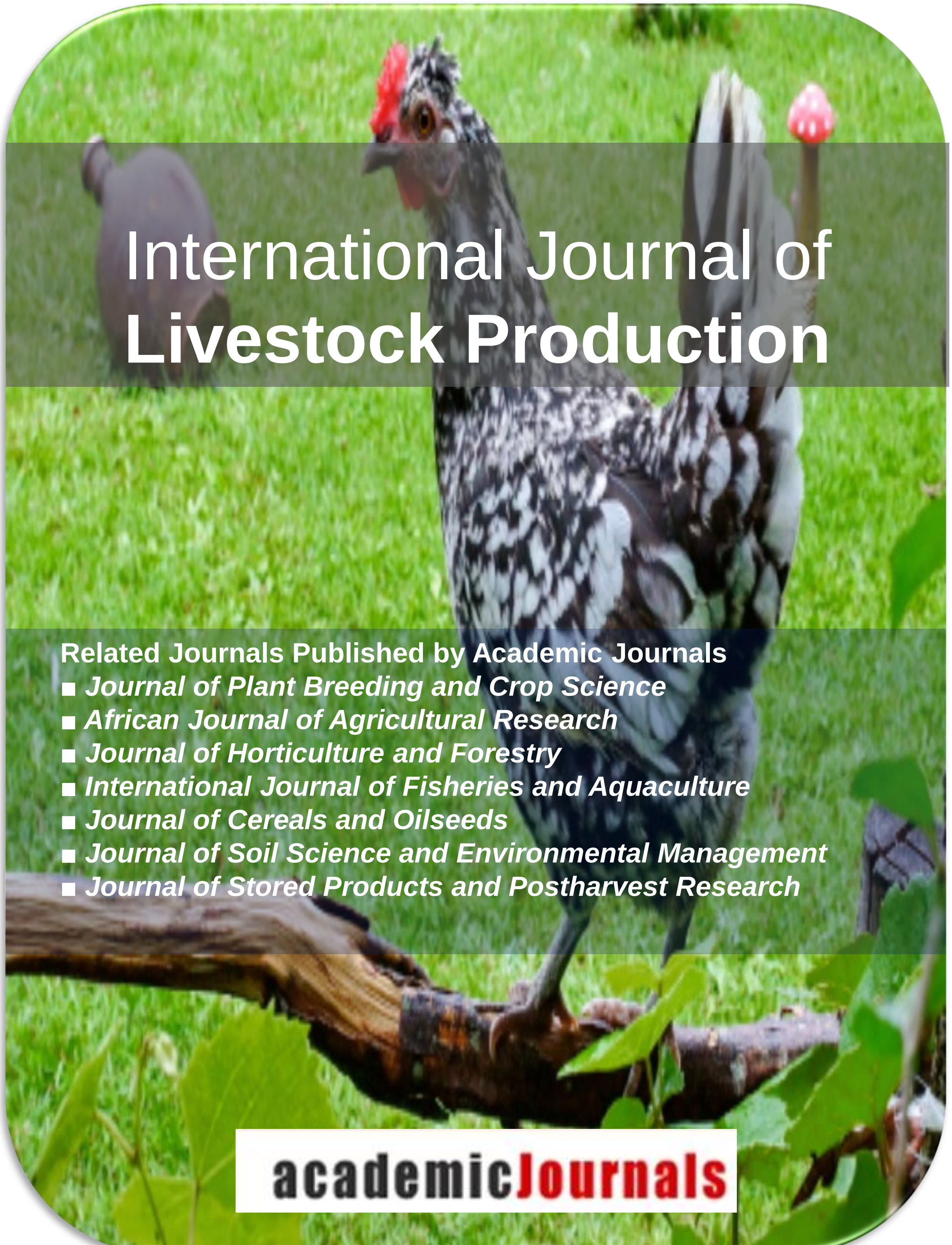
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