FACTORS AFFECTING MILK YIELD, LACTATION LENGTH AND MILK COMPOSITION OF DUAL-PURPOSE CATTLE IN ASHANTI REGION OF GHANA

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DECLARATION

STUDENT'S DECLARATION

I, Ismail Coffie, hereby declare that with the exception of references to other people's work which have been duly acknowledged, this dissertation is the result of my own work and it has neither in whole nor partially been presented elsewhere.

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SUPERVISORS' DECLARATION

I, hereby declare that the presentation of this dissertation was supervised in accordance with the guidance of dissertation laid down by the Unversity of Education, Winneba.

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DEDICATION

This work is wholeheartedly dedicated to Almighty Allah; my beloved mother, Akua Rabbi; Wife, Mariam Amponsah; all my brothers and sisters; and my late father, Kofi Baah Yakuub Coffie.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PLATES

LIST OF TABLES

LIST OF ABREVIATIONS AND ACRONYMS

AND	Atwima Nwabiagya District
AnGR	Animal Genetic Resources
AOAC	Association of Official Agricultural Chemist
BCS	Body Condition Score
CAADP	Comprehensive African Agriculture Development Programme
cm	Centimetre
DA	Displaced Abomasum
DAGRIS	Domestic Animal Genetic Resources Information System
DelPHE	Development of Partnership in Higher Education
DHIA	(Holstein) Dairy Herd Improvement Association
EJD	Ejisu Juaben District
ESD	Ejura Sekyedumase District
FAnGR	Farm Animal Genetic Resource
FAO	Food and Agriculture Organization
GE	Genotype by Environment
GEI	Genotype by Environment Interaction
GSH	Ghana Shorthorn (WASH)
ILRI	International livestock Research Institute
LL	Lactation Length
MoFA	Ministry of Food and Agriculture
SAS	Statistical Analysis System
SG	Sokoto Gudali
SGC	Sanga-Gudali Crossbred
SNF	Solids-non-fat
SSD	Sekyere South District
TL	Teat Length
Ts	Teat Size
TS	Total Solids
UBC	Udder Base Circumference
UEW	Unversity of Education, Winneba
US	Udder Size
WASH	West African Shorthorn
WF	White Fulani

ABSTRACT

The objective of this study was to determine factors affecting milk yield, lactation length and milk composition of smallholders' dual-purpose cattle in the Ashanti Region. Specifically it was intended to assess the effect of breed and non-genetic factors on (1) average value of milk yield, (2) lactation length of cows and (3) percentage milk components of various breeds of local cows. The study was conducted in four Districts of the Ashanti Region from 2012 to 2014. The cattle used for the study comprised 328 dual-purpose cows. Longitudinal survey was used with purposive sampling techniques. The cows were kept under farmers own practices and care with or without feed supplementation. Fresh milk samples from various breeds of cows were analysed for percentage composition of protein, fat, lactose, cholesterol, solid-non-fat and total solids. Lactation lengths were assessed by monitoring the date of calving to the date of weaning. All data were analysed using Generalized Linear Model Type III procedure of SAS. Results on average milk yield indicated that breed, parity, season of lactation, teat size, feed supplementation and body condition score (BCS) influenced ($p<0.01$) average milk yield, whereas udder size had little effect. Average daily milk yield per cow across breeds was 2.0 litres. Average daily milk yield per cow for West African Shorthorn (WASH), N'dama, Sanga, White Fulani, Sanga-Gudali crossbred and Sokoto Gudali were 1.5, 1.5, 1.9, 2.0, 2.8 and 3.5 litres ($p<0.01$), respectively. Milk yield increased ($p<0.01$) with increasing parity and dropped after the sixth parity. Small, medium and large teat sizes had daily milk yield of 2.0, 2.5, and 2.7 litres ($p<0.01$), respectively. Average daily milk yield per cow receiving regular and occasional feed supplementation, and no feed supplementation were 2.8, 2.2, and 1.9 litres ($p<0.01$), respectively. Lower BCS (≤ 2) and extremely high BCS led to reduced milk yield. Study on lactation length (LL) revealed that breed, feed supplementation and BCS influenced ($p<0.01$) LL whilst farm location, season of lactation, parity of cow and sex of calf had little ($p>0.05$) effect. Average LL across breeds was 246.4 days with minimum and maximum being 155 and 303 days, respectively. Mean LL for Sokoto Gudali, White Fulani, Sanga-Gudali cross, Sanga, West African Shorthorn (WASH) and N'dama were 278.1, 255.7, 262.5, 260.7, 214.5, and 261.2 days, respectively. West African Shorthorn had the least ($p<0.01$) LL whilst similar ($p>0.05$) LL were recorded for all the other breeds. The shortest mean LL was observed in cows provided with no supplementation whilst regular and occasional supplemented cows had similar ($p>0.05$) LL. Lactation length of 270.7, 257.6 and 237.9

days ($p<0.01$) were recorded for BCS 4, 3, and 2, respectively. Thus, LL significantly increased ($p<0.01$) as body condition score increased up to BCS 4. Percentage milk components of various dual purpose cows were significantly ($p<0.01$) influenced by breed and season. Parity and stage of lactation had little ($p>0.05$) effects on percentage components of fresh milk, however, the latter influenced ($p<0.01$) cholesterol levels. Gudali, and Sanga-Gudali crossbred had similar ($p>0.05$) percentage protein and fat whereas other breeds differed ($p<0.01$). Protein and solids-non-fat components were low ($p<0.01$) in major rains whilst lactose and total solids increased ($p<0.01$) with increasing intensity of rains. There were important interaction effects between breed, stage of lactation and season on percentage protein, fat, lactose and solid-non-fat components. It was concluded that given optimum environmental conditions, the dual-purpose cows in good body condition could provide relatively improved productive performances.

Key words: *average milk yield, breed, dual-purpose cattle, lactation length, milk composition, non-genetic factors, longitudinal survey.*

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

Animal industry, particularly cattle production has proven to be a satisfactory source of food for mankind all over the world (FAO, 2011) and it has beneficially improved man's livelihood**.** Cattle meat and milk production have been greatly improved by selective breeding and feeding (Shook, 2006) and management practices (von Keyserlingk *et al*., 2009). Today, it is common for cows of high yielding breeds, like the Holstein-Friesian, to produce 12,000 kg milk per lactation (Jorritsma *et al*., 2008).

The high yielding exotic dairy cattle (Friesian and Jersey) are unable to withstand the warm climatic condition in Ghana (Koney, 1996) and that has diverted the interest of smallholder farmers from keeping these breeds to local dual-purpose cattle. The production of dual-purpose cattle for high milk yield and lactation length through the upgrading of local West African Shorthorn (WASH) and N'dama to Sanga cattle with exotic dairy or the Zebu (Sokoto Gudali and White Fulani) cattle by means of crossbreeding, selection and artificial insemination is crucial (MoFA, 2004). Conservation and sustainable use of the dual-purpose cattle are important because of the multiple benefits offered by these local breeds (Barnes *et al*., 2012) including disease resistance and acclimatization to harsh climatic condition**.**

The dual-purpose cattle contributes to the diverse animal genetic resources, especially in the developing world, and play a key role in economic development in the rural and peri-urban areas (FAO, 2007b; 2011). These animal resources continue to perform important social, cultural and religious functions in indigenous and local communities today. The cultural importance of local cattle is frequently a key factor in *in situ* conservation (FAO, 2007b). These dual-purpose cattle furnish smallholder farmers with food security, income, and poverty alleviation. Milk and meat obtained from these animals apart from being good sources of amino acids, calcium and vitamins, are consumed in all parts of the world (FAO, 2011). Milk is inevitable food component which provides antibodies and essential amino acids for all humans and animals in early developmental stage of life. Besides, production of local cheese, Wagashie is highly lucrative venture for women and herdsmen's families (Annor, 2012). Recent investigations have revealed that dairy calcium offset cholesterol effects on dairy fats, thereby reducing the risk of cardiovascular disease (Lerenzen and Astrup, 2011), serving as a means of weight maintenance (Dougkas *et al*., 2011), and lowering risk of diabetes (Fumeron *et al*., 2011).

To realise the above mentioned merits at the smallholder farms may be dependent on dual-purpose cattle breed capable of producing reasonable milk yield at optimum lactation length. These cattle should be adapted to the prevailing environment that would not adversely affect their productivity and milk components (Johnson, 1991). Genotypes and non-genetic (environmental) factors influencing the performances of the local cattle need to be investigated for future improvement and sustainable production at the smallholders' level.

1.2 Problem statement

Records on breed and productive abilities of cattle kept by smallholder farmers in Ashanti Region are hardly traced and therefore make field studies of various dual-purpose cattle on-farm difficult. Influx of different breeds of cattle in an attempt to increase productivity through crossbreeding, genetic manipulations, and selection has the tendency to heighten genetic erosion (Rege and Okeyo, 2006). Genetic erosion is a problem of national and international concern, and a number of animal breeds are at risk of extinction (FAO, 2007a).

Diseases such as trypanosomiasis, dermatophilosis and heartwater jeopardized the dream of keeping the high yielding exotic breeds, especially, Friesian, Jersey and their crosses in Ghana (Koney, 1996; Otchere and Okantah, 2001). Diversion from keeping exotic breeds to local ones are influenced by individual breed with lower production potential, poor management practices (Oppong-Anane *et al*., 2008) coupled with high temperature and humid environmental condition (Johnson, 1991). These factors are capable of reducing the fertility of the cows, thus negatively influencing reproduction and lactation (Pagot, 1992).

Besides, milk production by the local cattle is low (CAADP, 2010) with shorter lactation length (Aboagye, 2002) and it is largely obtained from smallholder farms mostly herded by Fulanis. Due to high demand of milk and other dairy products, imports account for 64 percent of the dairy products consumed in West Africa including Ghana (CAADP, 2010). Unlike on station studies on productive performances (e.g milk yield, lactation length, e.t.c.) of both local and exotic cattle (Kabuga and Agyemang, 1983; Osei *et al.* 1991; Ahunu *et al*., 1994; Aboagye, 2002; Darfour-Oduro *et al*., 2010), very little is known about effects of genetic and non-genetic factors influencing milk yield, and lactation length of dual-purpose cattle at the smallholders' farms.

There is also paucity of information on milk composition of various breeds of dual-purpose cattle and factors affecting individual milk components. According to Looper (2012) milk yield per cow tends to receive the most attention by producers, with very little concern given to the component of yields. Without adequate knowledge about milk fats and solids components of a particular breed, the usefulness of its milk for appropriate dairy product such as butter, cheese or powdered milk may be baffling.

1.3 Main objective of the study

The objective was to determine the factors affecting milk yield, lactation length and milk composition of smallholders' dual-purpose cattle in Ashanti Region.

1.4 Specific objectives

The specific objectives were to determine effect of breed and non-genetic factors (location, season, parity, feed supplementation, sex of calf, stage of lactation, teat and udder sizes, and body condition score) on:

i. average values of milk yield of breeds of dual-purpose cattle in the study area;
ii. lactation length of various breeds of local cows; and
iii. percentage milk composition (protein, fat, lactose, cholesterol, solid-non-fat and total solids) of breeds of smallholders' cattle in the study area.

1.5 Benefit of the study

This study would lead to provision of cattle breeds' productive potentials. Information generated can be used when selecting for high yielding dual-purpose cows with optimum lactation lengths. Milk composition data and the other findings can be utilised for further research. This study might facilitate promotion of smallholder dairying and development by highlighting the use of the dual-purpose cattle for improvement studies through selection, crossbreeding and artificial insemination (AI). Development of smallholder dairying is important in West African countries, first of all as a means of improving the nutritional status of poor farmers and secondly as a means of employment and income generation to poor families.

1.6 Limitation

Difficulty of some herdsmen to compromise with the researchers made the study a strenuous task. All farms studied had no animal identification scheme. Although permanent/indelible markers were used to number all cattle on which records had been taken, heavy rains normally washed out the identification marks thereby making repeated data taking difficult without detailed body description. No records were kept on productive and reproductive parameters by smallholder farmers in the study area and therefore information pertaining to animals' performances was given usually based on guesses.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Background to cattle production in Ghana

Livestock production plays an important role in the socio-cultural life in the farming communities as a partial determinant of wealth, offering bridal dowry and for use at various occasions and festivals such as births, funeral and marriages (Oppong-Anane, 1999). In spite of this, the livestock sector has received little attention in the past agriculture programmes of the country (MoFA, 2007).

Guinea, Sudan and Coastal Savannah zones have been the areas concentrated with the cattle production in the country (Otchere and Okantah, 2001). Nevertheless, the control of the tsetse flies infestation has increasingly promoted cattle farming in both the transitional and forest zones where they are sometimes integrated with plantation crops (Oppong-Anane, 1999; Oppong-Anane *et al.,* 2008).

The main cattle production system practiced in the country is the extensive beef production system and it is based mainly on extensive grazing system where animals are allowed to graze in the early hours of the day by smallholder herds and return to their various kraals in the evening (Oppong-Anane, 2013). Smallholder dual-purpose cattle production in Ghana is associated with the sharing of scanty milk produced by cows between herdsmen and calves (Oppong-Anane, 2013). Various policies such as breed replacement, selection within the local breed, and crossbreeding (local breeds X exotic ones) have been used in an attempt to improve milk production potentials (Aboagye, 2002). At the smallholder level, medication is minimal with some herdsmen doing self- medication (Eyitayani *et al.* 1993) and this may depend on the objective of the farmer.

Ghanaian local cattle currently kept include the West Africa Shorthorn (WASH) which can be of savanna or forest type, Sanga, Zebu (Sokoto Gudali, White Fulani), N'dama and Muturu (Aboagye, 2002). The Forest/Dwarf WASH is almost fading out in the country (Aboagye, 2002). Additionally, there are a number of exotic breeds like the Holstein–Friesian, Jersey, Red Poll and Santa Gertrudis, imported for research purposes and are bred as pure breeds or crossbreeds (Aboagye, 2002).

According to Oppong-Anane (2010) very few cattle farms fall under the semi-intensive system. In the northern savannah, cattle herd sizes are generally small, usually between 10 and 50 head (Otchere and Okantah, 2001). Ownership patterns are complex and the herd may belong to one owner, one family or one village. In the southern savannah, however, herds are generally larger in size, frequently between 50 and 200 head (Otchere and Okantah, 2001). This is commercial cattle production system owned mainly by professionals and businessmen living elsewhere (absentee farmers/owners) with little or no involvement in the management of their animals and are cared for by hired Fulani herdsmen (Otchere and Okantah, 2001; MoFA, 2004). A few farms belonging to state institutions also fall under this system. In this case, cattle may graze on sown pastures as well as natural pastures which are often improved with introduced forage legumes. There are few intensive cattle farms in the country (Oppong-Anane, 2013), although some institutions and individual smallholder farmers are trying to embark on zero grazing of cattle (Annor, Personal Communication).

2.1.1 History of development of dairy industry in Ghana

Several attempts have been made to promote dairying in Ghana (Otchere and Okantah, 2001; Aboagye, 2002). Exotic breeds including Holstein-Friesian, Jersey and Brown Swiss have been imported from Europe and elsewhere in conjunction with the use of WASH, in order to establish a productive (crossbreed) dairy industry in the country (Oppong-Anane, 1999). It is worth noting the time line of several efforts meant to establish dairying in the country as summarized by Kabuga (1989), Oppong-Anane (1999), and Aboagye (2002) as follows:

The first attempt at establishing a dairy enterprise in the country was by the Ministry of Agriculture at Nungua, in Accra, with WASH cattle which date back to 1941. The scheme was dropped after a few years of operation due to low milk production. In 1942, the Ministry of Agriculture imported a total of 117 Bunaji (White Fulani) cattle from Nigeria to start a dairy herd at Nungua. The Bunaji bulls were used to cross WASH cows. Most of the heifers were lost to Contagious Bovine Pleuropneumonia (CBPP);

In 1958, the first attempt at using temperate cattle for milk production in the country was initiated at ARS (Animal Research Station) and University of Ghana. This involved the use of one Jersey sire for a crossbreeding programme with WASH, N'dama and Zebu cows. The programme was suspended as a result of culling due to tuberculosis in 1978 to 1981 and theft of the replacement herd in 1981;

The State Farms Corporation imported 30 black and white cattle form Russia to set up a dairy farm at Adidome in the Volta Region in 1964. In 1967, the Ministry of Agriculture imported 100 in-calf heifers and 20 Friesian bulls from the United Kingdom to form a nucleus dairy farm at Amrahia in the Accra Plains. This was followed by importation of 400 Friesian cattle from Holland, 200 each in 1974 and 1976. The initial stock of Friesians imported was said to be for investigation purposes, and no emphasis was placed on obtaining pedigreed stock. The exploratory phase was devoted to survivability and maintenance of fertility status. In addition, University of Science and Technology, Kumasi, received 5 Holstein-Friesian heifers and 5 bulls from Canada in 1974.

In 1977, Sam and Sam Ltd., a private firm in Accra, imported 37 Brown Swiss cattle from Austria to set up a dairy farm. In 1978, Agro Mim Industries also established a dairy farm at Mim, in the Brong-Ahafo Region, with Jersey crosses from ARS. Thereafter, a few other individuals and companies attempted to set up dairy farms using available dairy animals in the country;

A total of 623 cattle were imported between 1964 and 1977, and at the moment a few farmers can boast of pure Jersey cattle in the Southern Ghana (Bekoe, 2011). Most of the crossbreeds of dairy cattle available are produced through artificial insemination with imported semen. It appears that the attempts at setting up a dairy industry in Ghana using pure exotic cattle have been difficult task. Challenges associated with the sustainable management of the pure exotic breeds for effective production and efficient utilization of their products may be attributed to a number of factors, the principal ones being housing, disease incidence, and shortage or unavailability of good quality feed year-round.

2.2 Breeds of local cattle in Ghana

Bos taurus including West African Shorthorn (WASH) and N'Dama; *Bos indicus*—White Fulani, Sokoto Gudali; and various crosses between the two breeds (Ghana Sanga) are the common local cattle found in the country (Otchere and Okantah, 2001; Oppong-Anane *et al*., 2008). Whilst local farmers have generally used the bigger *Bos indicus* breeds as sire breeds for crossing with the smaller indigenous taurine breeds, institutional farms have often used imported temperate taurine breeds either as pure breeds (males and females) or as sire breeds (semen) in crossbreeding with indigenous breeds (Aboagye, 2002).

2.2.1 The West African Shorthorn (WASH)

The WASH—*Bos taurus,* is the most populous breed, and according to Oppong-Anane (1999) they account for over 80% of the national population. It is derived from Shorthorns—*Bos taurus brachyceros*, (Rege, 1999). However, as a result of crossing of the indigenous WASH with White Fulani to produce a more stabilized Sanga (MoFA, 2004), to improve on its body size and level of milk production, WASH numbers constitute about 60% of the cattle population (Otchere and Okantah, 2001). Rege *et al.* (1994a) indicated that the numbers of Sanga are increasing at the expense of the WASH in Ghana. The biggest threat to the WASH now is from the numerically superior but ill-adapted zebu found in the West African sub-region, which, as a result of crossbreeding, is eroding the WASH genes (Otchere and Okantah, 2001; Aboagye, 2002).

The West African Shorthorn is also known as Ghana Shorthorn (GSH) or Gold Coast Shorthorn (Rege *et al*., 1994a; Aboagye, 2002; and DAGRS, 2007). It is believed to have arrived in the African continent 2500 BC (FAO, 1999). In general, the performance of the WASH (Savanna type) has been better than that of the Dwarf (Forest) type (Rege *et al.* 1994b).

They generally have short firm legs and short horn usually pointing forward. The term WASH is commonly used in Ghana to describe the breed (Aboagye, 2002). They have a high population towards the northwestern border around Bole, Tumu, Wa and Lawra which is similar to the population that is found in Ivory Coast and around Bouna in the Upper Volta (Aboagye *et al*., 1994; DAGRIS, 2007).

The average height of the Ghana shorthorn ranges from 105 cm to about 118 cm (based on whether it is a savanna or dwarf/forest type) though the pure breed type around Wa do not usually reach this size (Aboagye *et al*., 1994). The breed is tolerant to trypanosomiasis and tick born diseases like heart water (Maule, 1990).

The West African Shorthorn cattle are mainly used for meat, draught, and milk but lower yield is usually the consequence. WASH gives the lowest milk yield than all other indigenous breeds in Ghana (Aboagye, 2002). For instance, only 44 kg is produced in 29 days lactation period when the cows are directly milked on station. In general, Ghana Shorthorn cows do not let down milk in the absence of their calves (Aboagye, 2002). Using the weigh-suckle-weigh method, milk yield ranges from 384 to 774 kg—2.1 to 2.6 kg per day (with an average of 656.9 kg—2.48kg/d) over lactation periods ranging from 182 to 295 days (averagely 261±53 days) on station (Rege *et al*., 1994b). The highest yield was obtained when, in addition to 24 hours access to grazing, cows are fed a concentrate mixture composed of 60% maize or maize bran, 40% groundnut cake and minerals at a rate of 1.8 kg per head per day (Rege *et al*., 1994b).

2.2.2 N'dama cattle

The N'dama cattle are humpless longhorn of *Bos taurus longifrons* and they are synonymously known as Boenca, Boyenca, and Faouta Longhorn (DAGRIS, 2007). These hametic longhorn cattle breeds are believed to have originated from the first domesticated cattle populations of the Longhorn cattle in the region "Fertile Crescent", possibly 9000 BC (Payne and Hodges, 1997; Rege *et al*., 1994a). These are said to be the first cattle to be introduced to Africa via the land connection with Asia by nomadic people and have spread to the west and south of Egypt (DAGRIS, 2005). Archaeological findings, on the other hand, have led to the new theory that there was an African centre of domestication in the Sahara from southern Libya and north-western Niger to southern Egypt (Payne and Hodges, 1997).

N'dama cattle are also believed to have originated from the Fouta Djallon plateau in Guinea, and are now found in the whole of coastal West and Central Africa: Senegal, Gambia, Guinea-Bissau, Guinea, Sierra Leone, Cote d'Ivoire, western Mali, Ghana, Togo, Nigeria, Cameroon, Central African Republic, Gabon, Congo (Brazzaville), and Democratic Republic of Congo (former Zaire), particularly in the regions infested by tsetsefly (DAGRIS, 2005; 2007; ILRI, 2009).

N'dama are trypano-tolerant (Claxton and Leperre 1991; Dwinger *et al.,* 1992) and do well in poor pasture and resistant to tick born diseases (Mattioli *et al*., 1995) but are prone to rinderpest infections (Dwinger *et al*., 1992). Two types of N'dama may be distinguished; the Guinea N'dama and the Gambian N'dama. The Gambian N'dama is distinguished by their lighter colour and longer slightly better shaped horns (Dwinger *et al.,* 1992). Average weights for the N'dama female have been given as 97 kg, 142 kg, 147kg whereas males have 106 kg, 164 kg, 176 kg for 6, 12 and 18 months respectively (Dwinger *et al.,* 1992; ILRI, 2009)

The N'dama breed is multipurpose cattle with relatively low milk production, although partial milking is frequently carried out in the traditional herds of West Africa (Rege *et al.*, 1994b; Aboagye, 2002).

2.2.3 Zebu cattle

The Zebu cattle belong to the *Bos indicus*. They are found in the tropics and are usually kept for all purposes (Dwinger *et al.,* 1992; Tawah and Rege, 1996; Rege and Tawah, 1999, Rege *et al*., 2001). The zebu are of different types (Rege *et al*., 2001) but more importantly, in Ghana, the Sokoto Gudali and the White Fulani are distinguished with prominent humps and show similar characteristics such as head length, chest girth, body height, and body length (Tawah and Rege, 1996; Rege and Tawah, 1999). The White Fulani are long horned and commonly white coloured with black skins, ears, eyes, hooves, and muzzles. They are believed to originate from Sahara Desert around river Senegal and Lake Chad (Aboagye *et al.,* 1994). They have an average height of about 130 cm and 453 kg in weight at maturity (Rege and Tawa, 1999). They account for about 26 % of the cattle population in Ghana (MoFA, 2007). They have slender horns, medium-long (81-107 cm), curved upwards and outward (Rege and Tawa, 1999). White Fulani teats are well positioned and are of medium to reasonably large size (Tawah and Rege, 1996).

The Sokoto Gudali are of Nigerian origin and have relatively shorter horns (Tawah and Rege, 1996). They have characteristics greyish colour and well developed humps, large dewlap and compact fleshy body. They are of medium size averaging about 128 cm in height and 405 kg in weight at maturity and because of their docile nature; they can be used for work or draught (Dwinger *et al*., 1992). The zebu breeds have better milk production potentials than the taurine breeds (Aboagye, 2002).

2.2.4 Ghana Sanga

In Ghana, the Sanga is a crossbred between the humpless taurine breed (e.g. N'Dama and WASH) and the zebu (Aboagye, 2002; Oppong-Anane, 2013). The natural crossbred is believed to have been in existence for some time now and is also common in other countries. The Ghana Sanga is believed to have been among the recent derivatives (Rege, 1999). They constitute about 76% of cattle used for milk production of the smallholder dairy farms in the Accra plains of Ghana due to their ability to perform better than other local breeds (Obese *et al.,* 1999). The breed is located in drier areas of Ghana towards the Northern border and on the Accra plains (Obese *et al*., 1999). They have a mature weight of about 190-330 kg for males and 180-295 kg for females (Rege, 1999). As a crossbred, the Sanga varies in it characteristics, but those found in southern Ghana, are almost uniform type which are predominantly white, frequently with black colours on the ears and sometimes with black spots (Rege and Tawah, 1999). Its main uses in order of importance are: milk, meat, draught, and manure (Rege, 1999).

Some Government stations have bred a special Sanga which is an N'Dama × Sokoto Gudali cross, used for milk production. In Ghana, Amrahia farms under the Ministry of Food and Agriculture has bred Sanga developed from WASH dam and Friesian or Jersey sire for milk production purposes (Oppong-Anane, 1999; MoFA, 2004; 2007).

2.3 Classification of dairy cattle

2.3.1 Dairy cattle

Dairy cattle are bred for their ability to produce large quantities of milk from which dairy products are made (Rege, 1999). Historically, there were little distinction between dairy cattle and that of beef cattle with the same stock often being used for both meat and milk production (Aboagye *et al*., 1994; Rege, 1999). Today, dairy industries are well specialized to breed animal for milk production. Holstein-Friesian is known to be the higest milk producer among Jersey, Brown Swiss, and others in the world (Jorritsma *et al*., 2008). In Ghana, Sanga is mostly advocated to be used for milk production because it performs better than the WASH (Aboagye *et al*., 1994). Others such as N'Dama, Zebu, and selected WASH are also used at the smallholders' farms (Otchere and Okantah, 2001).

2.3.2 The Dual-purpose cattle

Dual-purpose cattle are, as the name implies, cattle adapted for production of both milk and meat (Aboagye *et al*., 1994; Rege, 1999), and in satisfactory proportions (MoFA, 2004). These animals are solely cows that should have good characteristics of meat and milk production. In Ghana for instance, the Sanga is purposely meant for meat and milk production (MoFA, 2004; Oppong-Anane, 2013). These cattle can potentially provide adequate food and income for their keepers (Otchere and Okantah, 2001). Therefore, their genetic and productive performances should be understood, sustained and then carefully tailored to specific production systems to improve their productivity (FAO, 2007b; Okeyo *et al*., 2010). All local breeds, N'dama, WASH, Sokoto Gudali and White Fulani, are reared as dual-purpose cattle by local farmers in Ghana.

2.4 Milk production of local cattle

Historical viewpoint of the origin of dairying lies in the developing countries, in Mesopotamia to be precise, at around 6000-7000 BC. From this region, milk production and milk consumption spread to other regions in Europe, North and East Africa, and Asia (Falvey and Chantalakhana, 1999).

The most common dairy cattle in most West African countries is the *Bos indicus* also known as Zebu (Millogo *et al*., 2008). *Bos taurus* (West African Shorthorn and N'dama) and their crosses with Zebu (the Sanga) have also been found contributing significantly to milk production chain. It is well known that the local cattle, as compared to foreign breeds, has a low milk yield although it is difficult to estimate the exact yield, as calves are usually allowed to suckle to stimulate milk let-down (Coulibaly and Nialibouli, 1998) or milk is shared between herdsmen and calves (Millogo, 2010). Milk production, especially, in West Africa varies with season, with higher milk yields recorded during the rainy season (Millogo, 2010). Dairy products contribute substantially to the human diet during the rainy season. In the dry season, however, milk production is far from sufficient. The low milk yield then becomes a problem, both for the farmers and consumers (Millogo *et al*., 2008).

Dairy production and development is important in West African countries because: firstly, it serves as a means of improving the nutritional status of poor farmers, and secondly as a means of employment and income generation to the poor families (Ndambi *et al*., 2007). Milk has been envisaged as a principal protein source, which could increase protein consumption in Africa (Millogo, 2010). In Ghana, locally produced milk is processed into a traditional fresh soft cheese called *wagashi* (CAADP, 2010; Annor, 2012).

It has been revealed recently that dairy calcium offset cholesterol effects on dairy fat/blood lipids, thereby reducing the risk of cardiovascular disease (Lerenzen and Astrup, 2011). Again, dairy product consumption can serve as a means of weight maintenance (Dougkas *et al*., 2011) and its intake has been found to be associated with lower risk of diabetes (Fumeron *et al*., 2011).

2.4.1 Milk yield

Unlike exotic milking cattle such as Holstein-Friesian which are capable of producing 12,000 kg milk in one lactation (Jorritsma *et al*., 2008), milk yield of local cattle for both taurine breeds and Zebu are low, though the latter surpasses the former in milk yield (Otchere and Okantah, 2001; Aboagye, 2002; Oppong-Anane, 2013). In Burkina Faso, lactation yields in Zebu cows have been reported to vary between 500 and 1,000 kg per lactation under practical farming conditions (Millogo, 2010). In Ghana, researchers have found out that cows of 6 to 9 years can give a maximum daily yield, ranging from 4 to 9 kg, which is attainable between 3 and 7 weeks after calving in the on-station WASH (Aboagye, 2002). The mean daily milk yield of some common breeds and their crosses identified by researchers is shown in Table 2.1.

Table 2.1: Mean daily milk yields of some common breeds and their crosses

Breed/ genotype	Mean milk Yield (kg/litres)	No.	Source	Production system
WASH	2.6	9	Ahunu *et al*. (1994)	On-station
	2.5	10	Rege *et al*. (1994a)	On-station
	1.1	-	Aboagye (2002)	On-station
Sanga	0.87	9	Aboagye (2002)	On-station
Sokoto Gudali	5.3	9	Aboagye (2002)	On-station
FriesianX WASH crossbred	6.0 - 6.4	61	Ahunu *et al*. (1994)	On-station
	5.9 – 6.3	65	Aboagye (2002)	On-station
FriesianX Gudali crossbred	7.9 – 11.4		Ahunu *et al.* (1994)	On-station

No.= Number of observation
Adapted from Annor (1996), and Aboagye (2002).

2.4.2 *Factors affecting milk yield of cows*

Many factors can be attributed to the low milk production in West African countries. The production systems are mainly extensive (Millogo, 2010), characterized by low investment with resultant low output (Ngongoni *et al*., 2006). Factors limiting milk production in West Africa and the tropics as a whole, according to Pagot (1992), include genetic/breed factors, and non genetic components embracing feed resources, climatic factors, sociological and pathological factors.

2.4.2.1 *Genetic factors*

Milk yield is largely determined by genetic factors that depict low genotypic potential of the indigenous animals (Millogo, 2010), although milking frequency and efficiency of stripping can significantly affect milk yield per cow (De-Peters *et al*., 1985; Gisi *et al*., 1986). According to Jonhson (1991), milk yields are product of animal genetic and environmental interactions. Pagot (1992) contended that cattle breeds which originate from the tropics generally have limited genetic potential for milk production and remain mediocre producers (500-1500 kg per lactation) even when the best possible husbandry condition have been provided for them. However, these breeds are acclimatized to the prevailing climatic condition.

2.4.2.2 Non-genetic Factors

Management and Environmental Factors

Management of dairy animals can have effects on cows' productive performance (Bee *et al*., 2005). It has been found that local dairy cows and exotic breeds (Holstein-Friesian and Jersey) kept under different management in a given environment equally perform differently (McDonald *et al.*, 2011). Ngongoni *et al.* (2006) noted that Friesian and Jersey managed at commercial farms in Zimbabwe produced 21.8 and 15.4 litres of milk/day respectively whilst those on smallholder farms yielded 7.0 and 6.1 litres/day. Different management system perhaps good housing, routine health checks and feed supplementation may account for higher yield at the commercial farms. Additionally, Lateef *et al*. (2008) observed that in Pakistan, imported Friesian cows performed better than the farm born ones, resulting from differences in management prior to productive stages.

In addition, environment and location also play a critical role in both local cattle and exotic dairying (Ngongoni *et al.*, 2006). Poor environmental adaptation hindered survival of the exotic dairy breeds (e.g. Holstein–Friesian and Jersey) and their crosses in Ghana (Otchere and Okantah, 2001). Exotic cattle introduced to the country were found to require high levels of nutrition and management in the humid Ashanti region (Kabuga and Agyemang, 1983; Aboagye, 2002) and were also adversely affected by heat stress on the Accra Plains (Okantah, 1992). The local breeds kept at on-station perform better than those maintained at the smallholders level (Annor, 1996).

Diseases

Diseases such as trypanosomiasis, dermatophilosis and heartwater jeopardized the dream of keeping the high yielding breeds (Koney, 1996; Otchere and Okantah, 2001). This is because of high tsetseflies (*Glosina spp*) bites, ticks infestation and poor adaptation to high temperatures and humid environment (Pagot, 1992; Otchere and Okantah, 2001).

Nutrition/supplements

Major limitations to milk production in peri-urban areas of West Africa are: low availability of feed and water, and poor infrastructure (Millogo *et al*., 2008; Millogo, 2010). Annor (1996) noticed that local cows (WASH, N'dama and Zebu) supplemented in addition to natural grazing regimes produced higher quantity of milk. FAO (2013) stated that, adequate nourishment through supplementation and management early in life improves performance, health, milk production and longevity. Adequate nutrition is required to meet cows' metabolizable energy for lactation (McDonald *et al.,* 2011). This provides benefits in twofold: less health issues, and more milk production at optimum lactation period combined with equal or even lower raising costs (FAO, 2013).

Parity of cow

Parity indicates the number of births an animal has experienced. Daily average milk yield is affected by parity (Darfour-Oduro *et al.,* 2010). According to Epaphras *et al.*

(2004), Hatungumukama *et al.* (2006), and Afzal *et al.* (2007) milk yield of cows are low at parity one and increase with increasing parity and decline after fifth to sixth parities. On the contrarily, Hatungumukama *et al.* (2008) and Darfour-Oduro *et al*. (2010) found different observations when Friesian cattle were used for milk production in Burundi and Ghana, respectively supposedly as a result of humid environmental effect. Darfour-Oduro *et al*. (2010) reported that daily average milk yield gradually declined from second parity towards the sixth parity for Friesian-Sanga cows; whilst in Friesian cows in Burundi, the milk yield was undulating (Hatungumukama *et al.,* 2008)

Season of lactation

Seasons influence feed and forage availability as well as quality and quantity of the feed resources (Ngongoni *et al*., 2006). As forages grow they tend to accumulate more fibre at the expense of the nutritive components (McDonald *et al*., 2011). The highest milk yield is usually recorded in major rains (Epaphras *et al.,* 2004; Bee *et al.,* 2005) where feed and forages are in abundance.

Many authors have reported low daily milk yield during the dry and hot periods (Ageeb and Hayes, 2000; Epaphras *et al*., 2004; Hatungumukama *et al.,* 2006). This is one of the many constraints that have effect on milk production in the tropics; that is, the scarce availability of natural forages during the drier seasons (Ngongoni *et al*., 2006). High temperatures during the dry season tend to reduce feed intake, and with the resultant low milk production (Ageeb and Hayes, 2000). In accordance with Epaphras *et al*. (2004) the critical period, in terms of daily average milk production was from December to February, a period of high ambient temperature and low rainfall.

Body condition score

Body condition score (BCS) is a subjective measure of available tissue reserves and can therefore be used to indicate energy balance of the dairy cow (Loker *et al*., 2010). It has been reported that increased BCS is genetically and favourably linked with health and fertility traits (Berry *et al*., 2003; Bastin *et al*., 2010). It has therefore been suggested that BCS is moderately heritable and may be selected for without a large negative impact on milk production (Loker *et al.,* 2010). It is imperative to note that BCS is not genetically correlated with fat percentage (Loker *et al.,* 2010). Body condition score is a moderately heritable trait across lactation and parity.

Dairy cows have physiological ability of providing nutritional substances from their body tissues by losing "body condition" for about 40 to 100 days (Gergovska *et al*., 2011). They restore the lost body reserves after calving and afterwards (Koenen *et al*., 2001; Coffey *et al*., 2004; Pryce and Harris, 2006). The interest in this mechanism is the intensive transgeneration genetic selection towards increase of the total milk yield per lactation and at the beginning of lactation (Gergovska *et al*., 2011). Body condition scores can be used on both heifers and cows, although primarily they are used on the lactating dairy herd. Body condition scores greater than 3.75 at calving can reduce dry matter intake by 1.5 to 2.0 % for every 0.25 BCS increase over 3.75 (Varga and Ishler, 2007). Therefore, monitoring feed intake and days to peak milk production to determine if cows are managed properly with adequate, but not excessive, body condition is crucial (Varga and Ishler, 2007).

Loss of BCS after calving has significant effect on milk yield for 305 days lactation and the highest is the milk yield of cows with the greatest loss of BCS after calving

(Gergovska *et al*., 2011). Cows from Friesian and Brown Swiss with low BCS at calving from 2 and 2.5 points have the lowest milk yield for 305 days after calving. The milk yield and lactation period of cows with low BCS (≤ 2.5 points) is by about 1400 kg lower than that of cows with BCS ≥3.5 points (Gergovska *et al*., 2011).

2.4.3 Lactation length

Lactation length, defined as the interval (days) between day of calving and drying off, and milk yield are two important traits of dairy animals which might be dictated by genotype and environmental/non-genetic factors (Afzal *et al*., 2007). Darfour-Oduro *et al*. (2010) identified that breed, individual difference and season of calving affect on-station lactation length of Sanga and Friesian-Sanga cows. In Pakistan, lactation length of Nili Ravi Buffaloes has been identified to influence milk production and may range from 182 to 447 days (Afzal *et al*., 2007). In Uganda, lactation length ranges from 165 to 255 days on the basis of the management practices (Kugonza *et al*., 2011).

2.4.3.1 Factors affecting lactation length

Like milk yield, lactation length is also affected by factors which include genotype, supplementation, parity, and season of calving (Bajwa *et al*., 2004; Afzal *et al*., 2007; and Darfour-Oduro *et al*., 2010).

Breed

It has been noted that Sokoto Gudali, together with Bunaji, Shuwa Arab and Kuri are regarded as good milk producers under traditional husbandry (Aboagye, 2002). Total milk yield per lactation is determined by the length of lactation (M'hamdi *et al*., 2012). Acoording to Bajwa *et el.* (2004), Sahiwal cattle breed of Pakistan recorded mean lactation length of 248.0 days and it is considered as one of the best cattle breed for milk production in tropical conditions. In Ghana, Aboagye (2002) revealed that on-station studies on local breeds' lactation lengths of WASH, Sokoto Gudali, and N'dama range from 29-261 [or 295 by Rege *et al*. (1994b)], 167-252, and 182-252 days respectively. Mean lactation period of on-station Sanga and Friesian-Sanga cows has been reported to be 164.1 and 201.1 days respectively (Darfour-Oduro *et al*., 2010).

Parity

Number of parity may have effect on the length of lactation (Watters *et al.*, 2010). It has been noticed that lactation 1, 4 and 5 have lower milk yield as lactation length advances (Epaphras *et al.*, 2004; Darfour-Oduro *et al*. 2010; Watters *et al.*, 2010). However, Afzal *et al*. (2007) and M'hamdi *et al*. (2012) established that there were no differences in lactation length on the basis of different parities or lactation number.

Sex of calf

Studies conducted by Afzal *et al*. (2007) on milk yield per lactation length of Buffaloes on the effect of sex of calf showed no significant effect. Habib *et al*. (2010) also reported that sex of calf born has little or no influence on lactation length (days), lactation yield (kg), daily milk yield (kg), and dry period (days) in Red Chittagong Cattle. Quesnel *et al*. (1995) conversely noticed in dairy cows that milk yield over lactation period of cows with female calves had significantly lower milk yield and lactation length than those with male calves (4131 versus 4214 respectively per lactation).

Season of calving

Bajwa *et al*. (2004) contended that calving year and season as environmental factors affected lactation length of Sahiwal Cattle in Pakistan. Warmest season calvers had lactation length of 251.0 days as compared to coldest season calvers where average lactation length was 243.8 days. Milk yield on the other hand had the opposite trend. Warmest season calvers produced 184 kg less milk (1361 versus 1545 kg) as compared to coldest season calvers (Bajwa *et al*., 2004). On the contrary, M'hamdi *et al*. (2012) noted that both lactation length and milk yield increased with decreasing dryer and warmer seasons.

Nutrition and management factors

Nutrition and management practices, year, and season in which lactation commences are the main environmental factors affecting lactation performance in cattle (Msanga *et al*., 2000; Epaphras *et al*., 2004; M'hamdi *et al*., 2012). It has been stated that profitable breeding can be achieved by keeping lactation duration, dry period and service period between optimal limits (M'hamdi *et al*., 2012). The yields of farm animals are the result of the combined effects of genotype and environmental conditions which include nutrition and all other management routines (Afzal *et al*., 2007; Darfour-Oduro *et al*., 2010; Looper, 2012). According to M'hamdi *et al*. (2012), provision of good feeding level for dairy cows boost up lactation performance.

Body condition score

Body condition score (BCS) of cow at breeding season of late has been considered to affect the lactation period (Watters *et al*., 2010). The most important areas that have been focused on are (1) the BCS of cow at the breeding time of lactation and (2) the changes in BCS from calving to time of breeding. It has been recommended that a cow should enter the dry period with a BCS between 3.25 and 3.75 (Watters *et al.*, 2010). Ensuring that the animal does not lose more than one point is important because of the increased chances of the cow being anovular—absence of ovulation (Watters *et al.*, 2010; Gergovska *et al.*, 2011). Gergovska *et al.* (2011) also noted that milk yield and lactation period of cows with low body condition score (≤2.5 scores) have 1400 kg lower and shorter LL than that of cows with BCS greater than 3.5 points. A herd of cattle in good body condition (BCS ≥3) will produce more, and will be less susceptible to metabolic disorders, disease, mastitis and reproductive problems (Patton *et al*., 1988).

2.4.4 Milk composition

Milk is composed of water, carbohydrate, fat, protein, minerals and vitamins (Heinrichs *et al*., 2005). Milk is secreted as a complex mixture of these components. The properties and importance of milk are greater and more complex than the sum of its components (Heinrich *et al*., 2005). Composition of milk varies from cow to cow and differs from the various breeds. Milk solid components include protein, fat, lactose and minerals (Schroeder, 2012). Milk is, therefore, a variable biological fluid across indigenous breeds and fat content of milk shows a wide variation (Aboagye, 2002). Total solids, protein and ash contents of the milk were 10.6, 3.2 and 0.75%, respectively (Aboagye, 2002). However, comparable figures from other indigenous breeds (such as N'Dama, and White Fulani) are not available (Aboagye, 2002).

In addition to interspecies differences (Table 2.2**)**, the milk composition of any particular species varies with the individuality of the animal, the breed (in the case of commercial dairying species), health (mastitis and other diseases), nutritional status, stage of lactation, age, and interval between milking (O'Connor, 1995; Fox and McSweeney, 1998).

Cow's milk total protein content consists of mainly casein (80 %) and whey protein with traces of minor protein. Cow milk contains significant proportion of soluble casein (0.11g /100mL) which is about 5 % of the total casein as compared with that of buffalo's soluble casein (0.03 g/100 mL) of about 1 % of the total casein (Ahmad *et al.*, 2013). However cow casein concentration and diameter is lesser than that found in buffalo's milk (Ahmad, 2010). The percentages of milk protein and solid-non-fat (SNF) are higher when the cows were fed rations with higher energy (Kumaresan *et al.*, 2008). Cow milk protein increased with increase in feed intake and frequency, high non-fibre carbohydrates, and low fibre of less than 26 NDF (neutral detergent fibre), however, low crude protein decreases it when it is deficient in the lactating cow's diet (Looper, 2012). It has been found that average milk protein of cows ranged from 1.57 to 4.66 %, with an average of 3.05 % (Heinrichs *et al.*, 2005).

Fat is the most sensitive milk component, and is affected by a variety of factors, such as food management or nutrition, genotype, lactation and calving phase (Simoes *et al.*, 2014). Fat component in fresh milk is also influenced by seasons. Milk fat content ranged from 1.77 to 5.98 %, with an average of 3.76 % (Heinrichs *et al.*, 2005). Fat content of 4.11 % have been reported by Okantah (1992) for Sanga cattle in smallholders' farms whilst Aboagye (2002) observed that fat content ranges from 1.3 % in WASH to 5.1 % in the Sokoto Gudali on-station. Rege *et al*. (1994b) however contended that fat component for the WASH is 4.1 %. Increase in feed intake and frequency increase milk fat whereas underfeeding energy and high non-fibre carbohydrate (NFC) decrease milk fat content (Looper, 2012).

Cholesterol is a precursor of many important steroids including bile acids, vitamin D, and steroid hormones (Strzałkowska *et al*., 2009). It has been stated that the cholesterol content in cow's milk is affected by both genetic and environmental factors (Strzałkowska *et al*., 2010) and in addition, it is related to the proportion of somatic cell counts (Strzałkowska *et al*., 2009). Human organism assimilates 300-500 mg of cholesterol from the diet during 24 hours while 700-900 mg is created from acetyl-CoA as result of endogenous synthesis (Strzałkowska *et al*., 2009). The concentration of cholesterol in milk varies from 8.7 to 25.4 mg/dl (Strzałkowska *et al*., 2009). Studies have found a correlation between the cholesterol content of milk and the age of cows' stage of lactation (Turk *et al*., 2003), physiological condition (Polat and Cetin, 2001) and season (Paura *et al*., 2003).

Lactose is the principal carbohydrate in milk of all mammals, although it contains some trace amounts of other sugars, including glucose (50 mg/l), fructose, glucosamine, galactosamine, neuraminic acid and neutral and acidic oligosaccharides (Fox and McSweeney, 1998). Complex oligosaccharides constitute a large portion of lactose of milk and perform biological functions that are closely related to their structural conformation (Ahmad *et al*., 2013). According to Enb *et al*. (2009), percentage composition of cow's raw, pasteurized, sterilized and cream milk lactose are 5.00, 4.80, 4.70, and 4.20 respectively. Table 2.2 gives lactose contents of some important breeds of dairy cattle.

Solid-non-fat (SNF) constitutes protein, lactose, minerals, vitamins, and enzymes. The SNF is more vulnerable to the environmental temperature which indirectly reflect plane of nutrition (Kumaresan *et al.*, 2008). Changes in the feeding practices occur concurrently with the change in seasonal pattern of SNF.

Total solids consist of fat and solid-non-fat and its percentage composition ranges from 10.50 to 14.50 with the average of 13.00 (O'Mahony, 1988). Enb *et al*. (2009) however stated mean total solids to be 13.40.

Table 2.2: Milk composition of six breeds of cows

Breed	Fat (%)	Protein (%)	Lactose (%)	Ash (%)	Total Solids (%)
Ayrshire	4.1	3.6	4.7	0.7	13.1
Brown Swiss	4.0	3.6	5.0	0.7	13.3
Guernsey	5.0	3.8	4.9	0.7	14.4
Holstein	3.5	3.1	4.9	0.7	12.2
Jersey	5.5	3.9	4.9	0.7	15.0
Zebu	4.9	3.9	5.1	0.8	14.7

Adapted from Jensen 1995

2.4.4.1 Factors affecting milk composition

Factors that affect milk composition include genetics, stage of lactation, level of milk production, age of cow, environment, disease (for example, mastitis) and nutrition (Looper, 2012).

Genetic/Breed factors

Heinrichs *et al*. (2005) stated that genetics and inheritance account for major difference between cows' milk protein and fat content. Fifty-five percent (55 %) of the variation in milk composition is due to heredity, while 45 % is due to environmental factors such as feeding management (Schroeder, 2012). Heritability estimates for milk composition are fairly high at 0.50 (Looper, 2012). Heritability indicates the proportion of observed differences that are due to genetics, while the reciprocal is assumed to be due to environmental factors (Heinrichs *et al*., 2005). Jensen (1995) reported average composition of milk for some breeds of cattle as shown in Table 2.2. Level of production or yields of fat, protein, non-fat solids and total solids are highly related with milk yield (Looper, 2012).

The priority placed on each genetic trait of milk component depends upon its economic or profit impact (Looper, 2012). Milk yield per cow tends to receive the most attention by producers. However, component yields should not be overlooked. Genetic selection should be directed toward increasing fat, protein and non-fat solids yields. But, because component percentages tend to have negative genetic associations with yield traits, a change in these percentages is not likely to be achieved through genetic selection alone (Looper, 2012).

Comparison of chemical composition of buffalo's and cow's milk samples by Enb *et al*. (2009) revealed that fat, total protein, ash and total solids content in buffalo's milk were (4.9, 3.6, 0.76 and 13.4 %, respectively) higher than those detected in cow's milk (3.2, 3.2, 0.65 and 12.1 %, respectively). This is an indication that variation of milk compositions is due to differences in genetic constitution with respect to different species or breed.

Non-genetic Factors

Nutrition

Environmental factors such as nutrition and feeding management can have impact on yield more than the actual percent composition of the major milk constituents (Looper, 2012). It should also be realised that yields of fat, protein, non-fat solids, and total solids are highly related to milk yield (Varga and Ishler, 2007). The effect of the dietary intake of the cow on milk composition has been reported (Slots *et al*., 2009). Nutritional strategies that optimize rumen function also maximize milk production and milk components (Varga and Ishler, 2007). As cows consume more energy than they use to be, body weight is regained, losses in body condition are minimized and cows produce milk of normal fat and protein content. It is essential to meet the cow's requirement for both crude protein and rumen undegradable protein to avoid a negative impact on dry matter intake and fibre digestibility. Studies of diets containing no supplementary fat show that each one (1) percent increase in dietary protein, within the range of 9 to 17 percent results in a 0.02 percentage unit increase in milk protein (Looper, 2012). Nutrition or ration formulation changes are more strongly correlated to milk fat content than milk protein (Heinrichs *et al*., 2005). It is imperative to note that, high-producing cows eat 3.5 to 4.0 percent of their body weight daily as dry matter. If a herd is consuming less than 3.5 to 4.0 percent of body weight as dry matter, production of solids-corrected milk may be limited (Varga and Ishler, 2007)

Parity/Age

Parity or age can influence fresh milk components (Looper, 2012). Whilst milk fat content remains relatively constant, milk protein content gradually decreases with advancing parity/age. According to a survey of Holstein Dairy Herd Improvement

Association (DHIA) lactation records, milk protein content typically decreases 0.10 to 0.15 unit over a period of five or more lactations or approximately 0.02 to 0.05 unit per lactation (Looper, 2012). Milk fat falls about 0.2 % each year from the first to fifth lactation or parity (Heinrichs *et al*., 2005)

Season

Season dramatically affects milk fat and protein. The hot, humid months depress fat and protein content whereas a gradual increase of protein and fat in milk through the fall/dry period and peak levels occur in the colder months (Heinrichs *et al*., 2005). Similarly, the highest values for fat, total solids and SNF contents of Jersey milk are observed during the coldest months (Kumaresan *et al*., 2008). As temperatures increase, component levels are gradually decreased. These changes may be indicative of feed intake patterns, which are lower in warmth due to changes in weather and temperature. It has been realised, however, that seasonality influences milk composition of buffalo with fat content increase (5.27 to 5.70 %) in the dry season and similar concentrations of the other variables in both seasons (Simões *et al*., 2014).

2.5 Measurement of the effect of breed and non-genetic factors on traits

Breed effects on milk production traits including milk yield, lactation length and milk components can be determined by individual genotype (Ruvuna *et al*., 1984; Inchaisri *et al*., 2010). The yields of farm animals are the result of the combined effects of genotype and environmental conditions (GE). Whereas genotype may refer to a breed (e.g WASH) or offspring of sire, environmental factors or conditions may refer to non-genetic factors (Annor, 2011).

Environmental factors can be classified as factors with measurable effects (age, year, season, milking frequency, etc.) whereas factors with immeasurable effects include infectious diseases, parasitic infestations, etc.) (M'hamdi *et al*., 2012). The measurable effects can be determined and used in the management of the farm (Cilek and Tekin, 2006). Environmental/non-genetic factors such as year, nutrition, season of calving, age at calving, parity, different location and sex of calf affect productivity of milk production traits (Quesnel *et al*., 1995; Habib *et al*., 2010; Inchaisri *et al*., 2010; Looper, 2012). In order to increase yields of milk production traits, it is necessary to optimize the measurable environmental conditions to improve the genetic structure of animals and to develop an understanding of the factors affecting them (M'hamdi *et al*., 2012).

2.5.1 Measurement of the effect of non-genetic factors on traits

Measurement of the non-genetic factors can be done by assessing what can be seen (phenotype) resulting from both genotype and the environment (Rege and Okeyo, 2006). The measurement of the factors on animals' phenotypic traits of interest can be divided into three main categories (Rege and Okeyo, 2006) as follows: physical characteristics or measurements, performance characteristics and additive characteristics.

1. Physical characteristics or measurements include such characteristics as presence or absence of horns, coat colour, body length, withers height, heart girth, tail length, tail type, presence or absence of hump, fur type (wool versus hair) etc. Some of these traits (e.g. presence or absence of horns) have simple Mendelian inheritance and have been studied extensively, at least in temperate livestock. Others such as withers height, heart

girth and body length are obviously quantitative in nature. Physical characteristics are arguably the most commonly used criteria for breed or strain definitions.

2. Performance characteristics are the traits most familiar to animal breeders. In mainstream, animal production, they tend to be limited to such traits as milk production (milk yield, its quality, Lactation length, and milk composition), fertility, mortality, longevity, growth, meat production etc.

3. Adaptive characteristics include such traits as disease resistance, cold tolerance, heat tolerance, ability to utilise low quality feeds, and selective grazing.

2.6 Genotype by environmental interaction on traits

A genotype by environment interaction (GEI) occurs when animal differs in their ability to perform in different environments (Bryant *et al*., 2005). According to Gebreyohannes *et al*. (2014) GEI can be defined as a change in the relative performance of two or more genotypes measured in two or more environments. In general, GEI arises when the performance of the different genotypes is not equally influenced by the different environments (Falconer and Mackay, 1996). Interactions between genotype and environment can also be described as differences in the environmental sensitivity of genotype, or differences in the phenotypic plasticity of genotypes (Bryant *et al*., 2005). Mathur and Horst (1994) and Calus (2006) have defined genotype as breeds, lines, strains, families or sires, while environment has included factors such as time, location, nutrition, management and housing.

A significant interactions for traits ($p<0.05$; $p < 0.01$; $p<0.001$; e.t.c) is an indication that performance of different genotypes is not equally influenced by different environments (Gebreyohannes *et al*., 2014). For instance, dissimilarities in climate, management and feeding may be contributed to breed group differences in milk yield performance at two locations. When the same genotypes develop different phenotypes in different environments, then there is G × E differences between genotypes (Hammami *et al*., 2009). Importance of fixed factors has been recognised in farm animal genetic improvement and evaluation programmes since absence of interaction can lead to overestimation or underestimation of genetic parameter estimates (Annor, 2011). It is important in the formulation of animal production objective by aiding the producer to consider environmental factors within which an animal can give better performances (Hammami *et al*., 2009).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location and duration of study

The study was conducted in four Districts in Ashanti Region (Fig. 3.1), including Atwima-Nwabiagya, Ejisu-Juaben, Ejura-Sekyedumasi, and Sekyere South. The duration for the study one and half years, that is from September, 2012 to February, 2014.

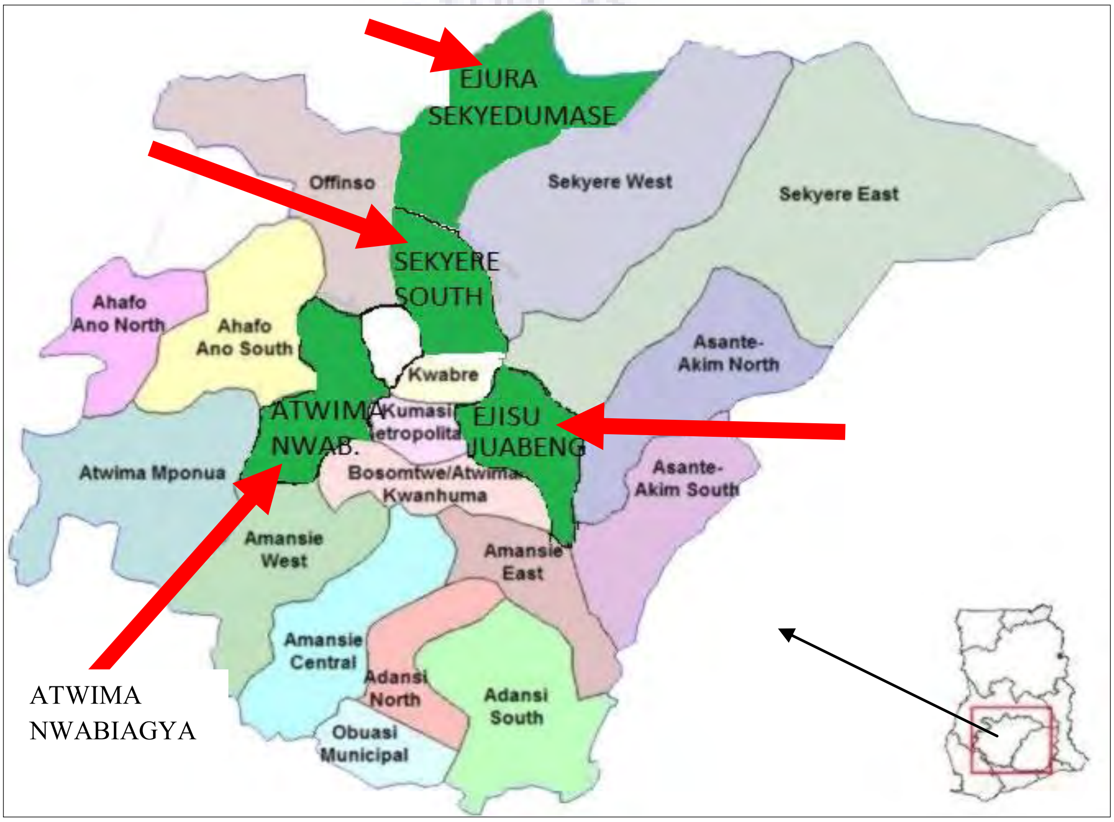

Fig. 3.1: Map of Ashanti Region showing the four selected districts in green colour (arrowed)

Ashanti Region is located in the transitional zone of Ghana and lies between longitudes 0.15'W and 2.25'W, and latitudes 5.50'N and 7.46'N. The region shares boundaries with four of the ten political regions; Brong-Ahafo Region in the north, Eastern Region in the east, Central Region in the south and Western Region in the south-west. It occupies a total land area of 24,389 km^2 representing 10.2% of the total land area of Ghana (Ghana Districts, 2006).

Ashanti is the third largest region after Northern (70,384 km^2) and Brong Ahafo (39,557 km^2) Regions. The region has a population density of 148.1 persons per square kilometre, also the third after Greater Accra and Central Regions.

More than half of the Ashanti Region lies within the wet, semi-equatorial forest zone. As a result of human activities and frequent bushfires, especially during the dry season, the forest vegetation of parts of the region, particularly the north-eastern area, has been reduced to savannah.

Ashanti Region has an average annual rainfall of 1270 mm and two rainy seasons. The major rainy season starts in March, with a major peak in May. There is a slight dip in July and a peak in August, tapering off in November. December to February is dry, hot, and dusty (Ghana Districts, 2006).

The average daily temperature of Ashanti region is about 27^oC. Much of the region is situated between 150 and 300 metres above sea level. The region is endowed with a spectacular geography-lakes, scarps, forest reserves, waterfalls, national parks, birds and wildlife sanctuaries (Ghana Districts, 2006). The common forage species grazed in the rangeland include elephant grass (*Pennisetum purpureum*), guinea grass (*Panicum maximum),* Centro (*Centrocaema pubescens),* giant star grass (*Cynodon* *plectostachyus*), and Gamba grass *(Andropogon gayanus*) and Carpet grass (*Axonopus sp),* (Plate 3.1.)

Plate 3.1: Types of Some forage fodder found in the Ashanti Region

3.2 Study design

Longitudinal survey design was used to obtain data on performance characteristics of the dual purpose cows in the Region. This involved collecting data from multiple subjects (e.g. milk production traits—milk yield, lactation length, milk components) on multiple occasions (e.g. at different seasons, parity levels, e.t.c.) in order to assess trends or changes in traits with time (Lynn, 2009).

3.3 Study population

The study population were dual-purpose cows in lactation. The breeds of cattle used for the study are shown in Plates 3.2a, b, and c.

3.4 Sample size

Three hundred and twenty eight (328) dual-purpose cows of the various breeds were sampled from the four districts in Ashanti Region for the study. The number of breeds of cows sampled included Sokoto Gudali (n = 11), Sanga–Gudali crossbred (n = 10), White Fulani (n = 121), Sanga (n= 130), WASH (n = 43) and N'dama (n = 13).

3.5 Sampling techniques

Purposive sampling procedure (ILRI, 1997; FAO, 2012) was employed for this study in the four districts. The same technique was also used to select animals on the basis of availability of those lactating, taking into consideration various breeds of cattle kept by smallholders. Selection of cows from each breed for milk compositional analysis was by random sampling.

Plate 3.2a: WASH cattle in the Ashanti region.

Plate 3.2b: N'Dama breed of the humpless longhorn (*Bos taurus longifrons*)

Plate 3.2c: Zebu cattle and their crosses

3.6 Management of animals

3.6.1 Housing and feeding

Animals were kept under three housing conditions; open kraal, open kraal with shelter, and completely roofed kraal (Plates 3.3a, b, c, d and e). The kraals were made in different dimensions, but in all, there were enough spaces for the animals. The dual-purpose cattle were kept in their respective Kraals with more than one bull in the evening till morning. For the young suckling calves, a small, roofed and protective Kraal (Plate 3.3e) were provided within or outside the main Kraal where they were kept away from the lactating cows until after next morning milking.

Plate 3.3a: Open kraal.

Plate 3.3b: Open kraal with a shelter (arrowed)

Plate 3.3c: A completely roofed kraal with concrete walls

Plate 3.3d: Roofed kraals with metallic and/or wooden walls.

Plate 3.3e: Types of calves' kraal found in the study areas.

Lactating cows were grazed on range grasses including Elephant/napier grass, Guinea grass and Centrosema leaves. Two types of grazing local cattle were seen at the study areas. First, animals were sent for grazing after milking at about 9:00 am and were returned to kraal in the evening (4:30 to 5:00 pm). The other grazing regime was that cattle were sent for grazing at dawn and were returned for milking around 9:30 to 10:00 am; they were sent for another grazing after milking (usually about 11:00am).

Feed supplementations (Plate 3.3f) were given by some farmers whilst others either gave occasional supplements or totally relied on the available range forage. Some of the feed supplements given to cows included cassava and plantain peels, brewers spent grain, and dried cowpea vines.

Plate 3.3f: Dry season feeding/supplementation

3.6 .2 Identification

Apart from one farm in Sekyere South district that used ear tags for identification of some of the cows, all other farms studied had no animal identification scheme (ear notching, ear tagging, or tattooing). The Fulani herdsmen used colour and other characteristics in identifying their animals. However, permanent/indelible markers were used to number all cattle on which records were taken.

3.6.3 Health care

Unlike farms in Sekyere South and Ejura Sekyedumasi districts that accessed Veterinary services, others hardly did so. Some farmers/herdsmen resorted to self-medication and/or used ethno-veterinary (indigenous) means in treating their animals. In some farms, animals were de-wormed with Albendazole 10% at three-month interval.

Special routine practices such as hoof trimming, dehorning, disbudding, dipping, and castration were not seen being practiced by farmers.

3.7 Methods of data collection

Each lactating cow's record included, district of origin, breed, parity of cow, season of lactation, udder size, teat size, type of feed supplementation and average milk yield. Partial milk yield was measured (once a day in the morning) in litres three times at four weeks interval in each of the three seasons (major and minor rains, and dry seasons) using a 500 ml (0.5litre) graduated infusion rubber bottle and funnel. Hand milking was used (Plate 3.4). Three hundred and twenty eight (328) cows consisting of Sokoto Gudali (n=11), SangaXGudali crossbreed (n=10), White Fulani (n=121), Sanga (130), WASH (n=43) and N'dama (n=13) were used in this study.

Plate 3.4: Hand milking and the measurement of fresh milk

Udder base circumference [UBC] and length [UL] from base of udder to the base of teat were measured and categorized into small (UBC≤69cm; UL ≤12cm), medium (UBC=70-80cm; UL=13-16cm) and large (UBC >80cm; UL≥17cm). Teat base circumference (TBC) and its length [TL] were measured and considered as small (TBC≤5cm; TL≤ 2cm), medium (TBC=6-8cm; TL=2.5-5cm) and large (TBC≥9cm; TL>5cm) (Plates 3.5 and 3.6).

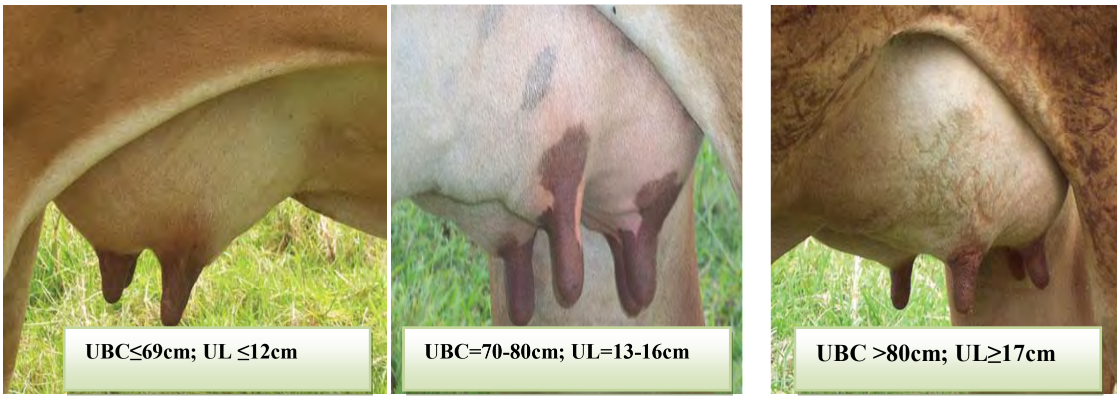

Plate 3.5: Small, medium and large udder sizes as identified on the field

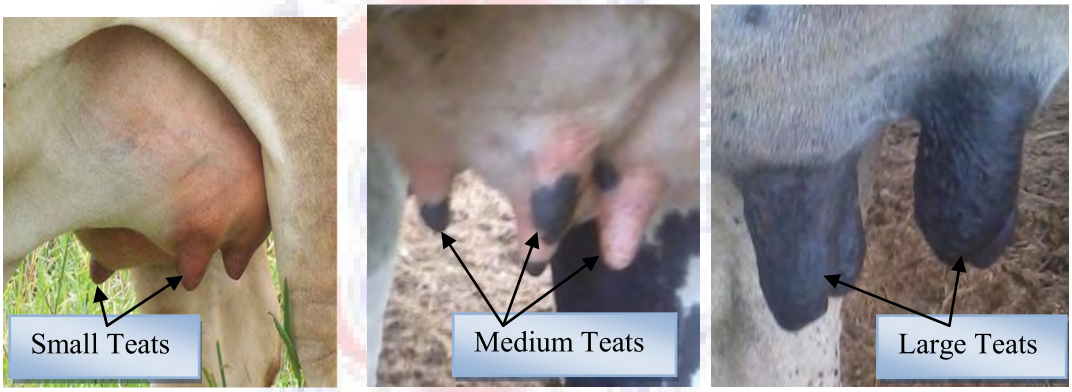

Plate 3.6: Different teat sizes identified on the field (small, medium and large from left to right)

Data on lactation lengths of dual-purpose cattle were determined by monitoring cows' date of calving, body condition score (BCS) at calving or the day of calving, parity of cow, season of calving, location of calving and date of weaning. Weaning of calves were observed to be characterized by dams unwillingness to allow their calves to suckle, marked reduction in daily milk yield to less than 0.1 litre/day, calves reluctance to suckle, and in some breeds loss of mothering abilities of cows and hostilely wild to herdsman. Lactation length was defined as the interval (days) between day of calving and weaning. The breeds of cattle used for the study included WASH (n=18), Sanga (n=43), White Fulani (n=25), Sokoto Gudali (n=12) Sanga-Gudali crossbreed (n=13) and N'dama (n=13).

A five scale BCS used in this study (Patton *et al.,* 1988; Keown, 2005) is defined as follows:

BCS 1:

Rump Area: Deep cavity around tail-head. No fatty tissue felt between pins. Pelvic bone easily felt. Skin is supple.

Loin Area: Ends of short ribs sharp to touch. Upper surfaces can be felt easily. Deep depression in loin. Cows after having a severe DA (Displaced Abomasum) are typically scored a 1.

BCS2:

Rump Area: Shallow cavity lined with fatty tissue at tail-head. Some fatty tissue felt under pin bone. Pelvis easily felt.

Loin Area: Ends of short ribs feel rounded. Upper surface felt with slight pressure. Depression visible in loin.

BCS 3:

Rump Area: No visible cavity around tail-head. Fatty tissue is easily felt over whole rump. Skin appears smooth. Pelvis is felt with slight pressure.

Loin Area: Ends of short ribs can be felt with pressure. There is a thick layer of tissue on top. There is only a slight depression in the loin.

BCS 4:

Rump Area: Folds of fatty tissue are visible around tail-head. Patches of fat are present around the pin bones. Pelvis is felt only with firm pressure.

Loin Area: Short ribs cannot be felt even with firm pressure. No depression is visible in loin between backbone and hip bone.

BCS 5:

Rump Area: Tail-head is buried in fatty tissue. Skin is distended. No part of pelvis can be felt even with firm pressure.

Loin Area: Folds of fatty tissue over short ribs. Bone structures cannot be felt. These cows are good candidates for fat cow syndrome.

Data were also gathered on milk composition (% protein, % fat, % lactose, % cholesterol, % total solids, and % solids-non-fat) of the various breeds; milk analysis was carried out at the Biochemistry laboratory of the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, in accordance with A.O.A.C. (2006). Breeds of cows used for this study included Sokoto Gudali (n=14), N'dama (n=9), Sanga (n=12), Sanga-Gudali crossbreed (n=13), WASH (n=14) and White Fulani (n=10).

Chemical analysis or proximate compositions of samples of range forage fodder including *Pennisetum purpureum*, *Panicum maximu,* and *Centrocema pubescens* were determined at the Animal Science laboratory of the KNUST, Kumasi, according to the procedure outlined by A.O.A.C. (2002). This was done to determine seasonal variation in their chemical components of crude protein, crude fibre, ether extract, ash, moisture and nitrogen free extract. The proximate compositions of the fodder are presented in Table 3.1.

Table 3.1: Average values of proximate composition of ranged Elephant/Napier grass, Guinea grass and Centrocema leaves as cattle fodder

FIXED FACTORS	N[1]	% CRUDE PROTEIN	% ETHER EXTRACT	% CRUDE FIBRE	% ASH	% MOISTURE	% NITROGEN FREE EXTRACT
DISTRICT[2]		*0.4859*	*0.9468*	*0.9732*	*0.1622*	*0.0698*	*0.7902*
AND	11	15.1±0.26	2.5±0.20	24.0±0.69	7.3±0.18	7.9±0.14	43.2±0.83
EJD	11	14.6±0.26	2.4±0.20	24.3±0.69	7.2±0.18	7.7±0.14	43.8±0.83
ESD	11	14.8±0.26	2.4±0.20	24.4±0.69	6.9±0.18	8.1±0.14	43.4±0.83
SSD	11	15.1±0.26	2.3±0.20	24.3±0.26	7.4±0.18	8.3±0.14	42.6±0.83
TYPE OF FODDER[2]		*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*
EG	16	13.2±0.21[b]	2.0±0.17[b]	24.6±0.58[b]	8.4±0.15[a]	7.1±0.12[b]	44.5±0.70[a]
GG	16	11.9±0.21[c]	2.0±0.17[b]	31.0±0.58[a]	8.5±0.15[a]	6.6±0.12[c]	39.9±0.70[b]
Centro	12	19.4±0.24[a]	3.2±0.19[a]	17.1±0.66[c]	4.6±0.17[b]	10.2±0.13[a]	45.3±0.79[a]
SEASON[2]		*0.0001*	*0.0002*	*0.0002*	*0.0001*	*0.0001*	*0.0040*
Major	20	16.7±0.20[a]	1.9±0.15[b]	21.8±0.52[b]	5.8±0.14[c]	8.5±0.10[a]	45.3±0.62[a]
Minor	12	14.7±0.24[b]	3.1±0.19[a]	24.6±0.66[a]	7.5±0.17[b]	8.1±0.13[b]	42.2±0.79[b]
Dry	12	13.3±0.24[c]	2.2±0.19[b]	26.5±0.66[a]	8.3±0.17[a]	7.3±0.13[c]	42.4±0.79[b]
Overall	**44**	**14.8 ± 0.13**	**2.2 ± 0.10**	**24.5 ± 0.34**	**7.2 ± 0.09**	**7.9 ± 0.07**	**43.4 ± 0.41**

[1] Number of samples taken
[2] Probability values of test of fixed factors
AND=Atwima Nwabiagya, EJD=Ejisu Juaben, ESD=Ejura Sekyedumase, SSD=Sekyere South District
EG=Elephant/Napier grass, GG=Guinea grass, Centro=Centrocema pubescens.
Means bearing different lowercase superscripts in the same column are significantly ($p<0.05$) different.

3.8 Statistical analysis

Data on (A) partial average milk yield, (B) lactation length, and (C) milk composition of the dual purpose cattle were subjected to least squares (LS) analysis using Generalized Linear Model (GLM) Type III Procedure (SAS, 2008) on the following fixed models:

(A) Average milk yield fixed model:

$$Y_{ijklmnopq} = \mu + D_i + B_j + P_k + S_l + U_m + T_n + X_o + C_p + DB_{ij} + DP_{ik} + DS_{il} + DU_{im} + DT_{in} + DX_{io} + DC_{ip} + BP_{jk} + BS_{jl} + BU_{jm} + BT_{jn} + BX_{jo} + BC_{jp} + PS_{kl} + PU_{km} + PT_{kn} + PX_{ko} + PC_{kp} + SU_{lm} + ST_{ln} + SX_{lo} + SC_{lp} + UT_{nm} + UX_{mo} + UC_{mp} + TX_{no} + TC_{np} + XC_{op} + e_{ijklmnopq}$$

Where: $Y_{ijklmnop}$ = the dependent variable or the trait being measured (average milk yield); μ = the population mean; D_i = the effect of the i^{th} District, i = 1, 2, 3, 4; B_j = the effect of the j^{th} breed, j = 1, 2, … 6; P_k = the effect of k^{th} parity of cow/dam, k = 1, 2, …, 7; S_l = the effect if l^{th} season of lactation, l = 1, 2, 3; U_m = the effect of m^{th} udder size, m = 1, 2, 3; T_n = the effect of n^{th} teat size, n=1, 3, 3; X_o = the effect of o^{th} supplementation, o =1, 2, 3; Cp = the effect of pth body condition, p 1, 2, …, 5; DB + DP + DS + DU + DT + DX + DC + BP + BS + BU + BT + BX + BC + PS + PU + PT_{kn} + PX + PC + SU + ST +SX + SC + UT + UX + UC + TX + TC + XC = corresponding 2-way interaction effects; and $e_{ijklmnpqr}$ = the error mean term.

Two-way interactions among fixed variables were not significant and therefore ignored.

(B) Lactation length fixed model:

$$Y_{ijkmnqrt} = \mu + D_i + B_j + S_k + L_m + P_n + X_q + C_r + DB_{ij} + DS_{ik} + DL_{im} + DP_{in} + DX_{iq} + DC_{ir} + BS_{jk} + BL_{jm} + BP_{jn} + BX_{jq} + BC_{jr} + SL_{km} + SP_{kn} + SX_{kq} + SC_{kr} + LP_{mn} + LX_{mq} + LC_{mr} + PX_{nq} + PC_{nr} + XC_{qr} + e_{ijkmnqrt};$$

Where: $Y_{ijkmnqrt}$ = trait being measured; μ = population mean; D_i = the effect of i^{th} District/location, i =1, 2, 3, 4; B_j = the effect of j^{th} Breeds, j = 1, 2, …, 6; S_k = the effect of k^{th} sex of calf, k = 1, 2; L_m = the effect of mth season, m 1, 2, 3; P_n = the effect of nth parity, p= 1, 2, … 5; X_q = the effect of qth supplementation, q =1, 2, 3; C_r = the effect of rth body condition, r = 1, 2, 3; DB, DS, DL, DP, DX, DC, BS, BL, BP, BX, BC, SL, SP, SX, SC, LP, LX, LC, PX, PC, and XC = corresponding 2-way interactions; and $e_{ijkmnqrtu}$ = the residual effect.

However, the two-way interactions among fixed variables were insignificant and therefore ignored.

(C) Milk composition fixed model:

$$Y_{ijkmn} = \mu + B_i + P_j + L_k + S_m + BP_{ij} + BL_{ik} + BS_{im} + PL_{jk} + PS_{jm} + LS_{km} + e_{ijkmn}$$

Where: Y_{ijkmn} = trait being measured (milk composition); μ = the overall mean; B_i = the effect of i^{th} breed; P_j = the effect of j^{th} parity, j= 1, 2, … 5; L_k = the effect of k^{th} stage of lactation, k= 1, 2, 3, 4; S_m = the effect of m^{th} Season of lactation, m = 1, 2, 3; BP + BL + BS + PL + PS + LS = corresponding interactions; and e_{ijkmno} = the random error term. Differences among means of significant effects were separated by probability of difference (PDIFF) procedure of SAS (2008).

CHAPTER FOUR

4.0 RESULTS

4.1 Milk yield

Effects of all fixed factors on partial average milk yield are shown in Table 4.1. The overall average milk yield per cow per day across breeds was 2.0 litres.

4.1.1 Effect of location on average milk yield

Different location had effect ($p<0.01$) on average milk yield. Ejura Sekyedumase had the highest milk yield (Table 4.1). Sekyere South, Ejisu Juabeng and Atwima-Nwabiagya recorded similar values ($p>0.05$).

4.1.2 Effect of breed

There were breed differences ($p< 0.01$) in average milk yield (Table 4.1).

Sokoto Gudali recorded the highest average milk yield, with the Sanga-Gudali crossbreed, White Fulani, and Sanga following in that order. West African Shorthorn and N'dama had similar ($p>0.05$) and the lowest milk yield.

4.1.3 Effect of parity

Parity of birth had a great influence ($p<0.01$) on average milk yield. Milk yield at the first parity was relatively low (Table 4.1). Thereafter, average milk yield assumed a sustained increase from second to sixth parities and then declined sharply at the seventh parity.

Table 4.1: Least square means and standard errors for the effect of breed and non-genetic factors on average milk yield

Fixed factors	Number of Animals	Average Milk yield (litters/cow/day)
LOCATION		***P = 0.0069***[1]
Ejura Sekyedumase	104	2.4 ± 0.11[a]
Sekyere South	144	2.1 ± 0.10[b]
Ejisu Juabeng	34	2.2 ± 0.13[b]
Atwima-Nwabiagya	46	2.1 ± 0.12[b]
BREED		***P< 0.0001***[1]
Sokoto Gudali	11	3.5 ± 0.22[a]
Sanga X Gudali	10	2.8 ± 0.17[b]
White Fulani	121	2.0 ± 0.09 [c]
Sanga	130	1.9 ± 0.09[c]
WASH[2]	43	1.5 ± 0.11[d]
N'dama	13	1.5 ± 0.15[d]
PARITY		***P = 0.0014***[1]
1	48	2.2 ±0.13[b]
2	64	2.5 ± 0.11[a]
3	60	2.7 ± 0.11[a]
4	52	2.5 ± 0.12[a]
5	22	2.5 ± 0.16[a]
6	12	2.6 ± 0.19[a]
7	7	1.9 ± 0.25[b]
SEASON OF LACTATION		***P ≤0.0001***[1]
Major rains	37	3.0 ± 0.17[a]
Minor rains	139	2.3 ± 0.13[b]
Dry season	91	1.8 ± 0.14[c]
UDDER SIZE		***P = 0.3492***[1]
Small	13	2.3 ± 0.20
Medium	149	2.4 ± 0.12
Large	105	2.5 ± 0.13
TEAT SIZE		***P ≤0.0001***[1]
Small/rudimentary	40	2.0 ± 0.15[c]
Medium	136	2.5 ± 0.13[b]
Large	91	2.7 ± 0.14[a]
SUPPLEMENTATION		***P ≤0.0001***[1]
Regular	43	2.8 ± 0.15[a]
Occasional	104	2.2 ± 0.11[b]
No supplementation	162	1.9 ± 0.10[c]
CONDITION SCORE		***P<0.0001***
2	29	1.6 ± 0.12[c]
3	128	2.4 ± 0.11[b]
4	165	3.0 ± 0.10[a]
5	8	1.7 ± 0.20[c]
OVERALL	**328**	**2.0 ± 0.02**

[1]P value = probability of effects of fixed factors; [2]WASH= West Africa shorthorn.
Means bearing different superscripts in the same column are significantly (p<0.05) different.

4.1.4 Effect of season of lactation

Season of lactation had significant ($p<0.01$) effect on average milk yield. The highest ($p<0.01$) milk yield was recorded in the major rainy season, followed by the minor rains, with the dry season recording the lowest (Table 4.1).

4.1.5 Effect of udder and teat sizes

Udder size had slight differences in mean milk yield values but they were not significant ($p>0.05$). Teat size, on the other hand, had significant ($p< 0.01$) influence on average yield. It was noted that milk yield increased with increasing teat size (Table 4.1).

4.1.6 Effect of feed supplementation

Effect of supplementation had significant ($p<0.01$) difference on the average milk yield. Regular feed supplementation gave the highest ($p<0.01$) milk yield followed by occasional, and no feed supplementations in that order.

4.1.7 Effect of body condition score

The study indicates that body condition score (BCS) had great influence ($p<0.01$) on average milk yield. The least average milk yield was recorded by BCS 2 which was not different ($p>0.05$) from that of BCS 5. Good average milk productive performances were recorded by BCS 3 and 4 with the latter having the best record ($p<0.01$) of the average milk production (Table 4.1).

4.2 Lactation length of dual-purpose cattle

The effects of breed and non-genetic factors studied on lactation length (LL) are shown in Table 4.2. The overall mean of LL across breeds was 246.3 days. Minimum and maximum LL were 155 days (in WASH) and 303 days (in Sanga), respectively.

4.2.1 Effect of location on lactation length

District had little or no influence ($p>0.05$) on LL (Table 4.2). Similar ($p>0.05$) LL was observed in all districts.

4.2.2 Effect of breed

Breed influenced ($p<0.01$) LL of the dual-purpose cattle. All breeds had similar ($p>0.05$) LL, except WASH that had the shortest ($p<0.01$) LL (Table 4.2).

4.2.3 Effect of sex of calf and season of calving

Cows did not differ ($p>0.05$) in LL among the sexes of calves and season of calving. This means that LL of cows giving birth to male and females were similar ($p>0.05$). Also, cows lactating in major and minor rains, and dry season had similar LL ($p>0.05$).

4.2.4 Effect of parity

Parity of cows had insignificant ($p>0.05$) effect on LL. The slight differences observed among parities (1 to 5) were inconsistent even though parity 5 had the longest LL.

Table 4.2: Least square means and standard errors for the effect of breed and non-genetic factors on LL of the dual-purpose cows

Factors	Number of observation	Lactation Length (days)
LOCATION		***0.4425***[1]
Ejura Sekyedumase	24	253.6 ± 6.3
Sekyere South	50	251.2 ± 5.0
Ejusu Juabeng	15	255.8 ± 7.8
Atwima Nwabiagya	35	261.1 ± 5.9
BREEDS		***0.0001***[1]
Sokoto Gudali	12	278.1 ± 13.0[a]
White Fulani	25	255.7 ± 5.1[a]
Sanga X Gudali	13	262.5 ± 11.2[a]
Sanga	43	260.6 ± 4.4[a]
WASH[2]	18	214.5 ± 6.9[b]
N'dama	13	261.2 ± 10.8[a]
SEX OF CALF		***0.3919***[1]
Male	66	253.7 ± 4.8
Female	58	257.1 ± 5.0
SEASON		***0.0963***[1]
Major	52	262.8 ± 5.1
Minor	40	254.3 ± 6.2
Dry	32	249.1 ± 6.1
PARITY		***0.0530***[1]
1	51	250.4 ± 5.9
2	25	243.4 ± 5.8
3	25	254.1 ± 5.8
4	19	252.6 ± 6.4
5	4	276.5 ± 11.1
SUPPLEMENTATION		***0.0004***[1]
Regular	25	265.7 ± 6.5[a]
Occasional	37	259.1 ± 5.5[a]
No supplementation	62	241.5 ± 5.4[b]
CONDITION SCORE		***0.0011***[1]
2	35	237.9 ± 6.0[c]
3	65	257.6 ± 5.2[b]
4	24	270.7 ± 7.1[a]
Overall	**124**	**246.3 ± 1.7**

[1] *=Probability value of main effects*

Means bearing different lowercase superscripts in the same column are significantly ($p<0.05$) different.

4.2.5 Effect of feed supplementation

Feed supplementation of lactating cows significantly ($p<0.01$) influenced LL. Dual-purpose cows supplemented regularly or occasionally recorded the longest LL whilst cows managed under no feed supplementation had the lowest ($p<0.01$) LL (Table 4.2).

4.2.6 Effect of body condition score

Body condition score (BCS) at the time of birth significantly ($p<0.01$) affected LL of the dual purpose cows (Table 4.2). Lactation length increased ($p<0.01$) with increasing BCS.

4.3 Milk composition of the dual-purpose cattle

Effect of breed, parity, stage of lactation and season on fresh milk protein, fat, lactose, cholesterol, solid-non-fat, and total solids of milk composition of the dual purpose cattle are presented in Table 4.3.

4.3.1 Effect of breed on milk components

Breed significantly ($p<0.01$) influenced milk protein of the dual-purpose cows. Sokoto Gudali and Sanga-Gudali crossbred had similar ($p>0.05$) and highest percentage milk protein (Table 4.3). Percentage milk protein of Sanga, WASH, N'dama and White Fulani were similar ($p>0.05$).

Percentage fat component of fresh milk was also significantly ($p<0.01$) affected by breed of cows. White Fulani had the highest ($p<0.01$) percentage fat and it was similar ($p>0.05$) to the value recorded by N'dama and Sanga. Gudali, WASH and Sanga-Gudali crossbred also had percentage fats that were alike ($p>0.05$).

Breed also influenced milk lactose component significantly ($p<0.01$) as shown in Table 4.3. Fresh milk percentage lactose found in Gudali, N'dama, Sanga and WASH were similar ($p>0.05$) and higher ($p<0.05$) than the average values obtained by Sanga-Gudali crossbred and White Fulani. Similar ($p>0.05$) values were recorded for Sanga-Gudali and White Fulani breeds.

Cholesterol levels in fresh milk of cows were significantly ($p<0.01$) determined by the breed of the cow. White Fulani and Gudali had the highest cholesterol level in fresh milk but the latter had similar ($p>0.05$) value as N'dama and Sanga (Table 4.3). Sanga–Gudali crossbred and WASH possessed the lowest percentage cholesterol level. On the contrary breed had little ($p>0.05$) effect on solid-non-fat (SNF) components.

Total solids (TS) of fresh milk were influenced ($p<0.01$) by genotype of the cows (Table 4.3). N'dama had the highest ($p<0.05$) mean value, though it was identical to values obtained by Sanga, and White Fulani. WASH had similar ($p>0.05$) value to that of Sanga and White Fulani but lower ($p>0.05$) than the values obtained for the N'dama. Sokoto Gudali and Sanga-Gudali crossbred had the lowest ($p<0.01$) proportion of TS.

4.3.2 Effect of parity on milk composition

This study reveals that, parity of cows had insignificant ($p>0.05$) effect on fresh milk's percentage protein, fat, lactose, cholesterol, SNF, and total solids (Table 4.3). Similar values for all these traits were obtained for the different parity levels.

Table 4.3: Least square means and standard errors for the effect of breed and non-genetic factors on milk composition of dual-purpose cows

Factors	N[1]	Protein (%)	Fat (%)	Lactose (%)	Cholesterol (%)	Solid-Non-Fat (%)	Total solids (%)
BREED[2]		***0.0005***	***0.0001***	***0.0023***	***0.0001***	***0.2655***	***0.0001***
Gudali	14	8.0 ± 0.25^{a}	2.9 ± 0.06^{b}	6.6 ± 0.15^{a}	0.69 ±0.03^{ab}	5.6 ± 0.08	13.7 ± 0.09^{c}
N'dama	9	6.8 ± 0.28^{b}	3.2 ± 0.06^{a}	6.7 ± 0.17^{a}	0.61 ± 0.04^{b}	5.4 ± 0.09	15.0 ± 0.10^{a}
Sanga	12	7.2 ±0.26^{b}	3.2 ± 0.06^{a}	6.6 ± 0.16^{a}	0.63 ± 0.03^{b}	5.6 ± 0.08	14.8 ± 0.10^{ab}
SangaXGudali	13	8.0 ± 0.20^{a}	2.8 ± 0.04^{b}	6.2 ± 0.12^{b}	0.54 ± 0.03^{c}	5.5 ± 0.06	13.7 ± 0.08^{c}
WASH	14	7.4 ± 0.25^{b}	3.0 ± 0.06^{b}	6.6 ± 0.15^{a}	0.57 ± 0.03^{c}	5.7 ± 0.08	14.5 ± 0.09^{b}
White Fulani	10	7.1 ± 0.27^{b}	3.3 ± 0.06^{a}	*6.1 ±0.17^{b}*	0.73 ± 0.04^{a}	5.6 ± 0.08	14.8 ± 0.10^{ab}
PARITY[2]		***0.7885***	***0.8663***	***0.9707***	***0.8548***	***0.6290***	***0.7402***
1	11	7.6 ± 0.26	3.1 ± 0.06	6.5 ± 0.16	0.62 ± 0.04	5.7 ± 0.08	14.5 ± 0.10
2	19	7.4 ± 0.22	3.1 ± 0.05	6.4 ± 0.14	0.61 ± 0.03	5.6 ± 0.07	14.4 ± 0.08
3	25	7.4 ± 0.18	3.1 ± 0.04	6.5 ± 0.11	0.62 ± 0.02	5.6 ± 0.05	14.4 ± 0.07
4	5	7.5 ± 0.39	3.0 ± 0.09	6.5 ± 0.24	0.66 ± 0.05	5.6 ± 0.12	14.5 ± 0.14
5	12	7.2 ± 0.26	3.1 ± 0.06	6.4 ± 0.16	0.63 ± 0.04	5.5 ± 0.08	14.4 ± 0.10
STAGE OF LACTATION[2]		***0.1913***	***0.6360***	***0.6553***	***0.0206***	***0.5149***	***0.6180***
1-10	39	7.6 ± 0.12	3.0 ± 0.02	6.6 ± 0.08	0.68 ± 0.01^{a}	5.6 ± 0.04	14.5 ± 0.05
11-20	20	7.8 ± 0.15	3.1 ± 0.03	6.6 ± 0.09	0.67 ± 0.02^{a}	5.7 ± 0.05	14.5 ± 0.06
21-30	9	7.3 ± 0.24	3.1 ± 0.06	6.5 ± 0.14	0.56 ± 0.03^{b}	5.6 ± 0.07	14.5 ± 0.09
31-40	4	7.0 ± 0.58	3.0 ± 0.13	6.2 ± 0.36	0.61 ± 0.08^{b}	5.4 ± 0.20	14.2 ± 0.22
SEASON[2]		***0.0001***	***0.0001***	***0.0001***	***0.8643***	***0.0001***	***0.0001***
Major	23	6.5 ± 0.21^{b}	3.3 ± 0.05^{a}	10.1 ± 0.13^{a}	0.62 ± 0.03	4.3 ± 0.07^{b}	16.0 ± 0.08^{a}
Minor	23	7.9 ± 0.21^{a}	2.9 ± 0.05^{b}	4.6 ± 0.12^{b}	0.63 ± 0.03	6.2 ± 0.07^{a}	13.6 ± 0.08^{b}
Dry	26	7.9 ± 0.20^{a}	2.8 ± 0.04^{b}	4.5 ± 0.11^{b}	0.64 ± 0.03	6.1 ± 0.06^{a}	13.5 ± 0.07^{b}
[1] **Overall**	**72**	**7.7 ± 0.07**	**3.0 ± 0.02**	**6.4 ± 0.04**	**0.65 ± 0.01**	**5.7 ± 0.02**	**14.3 ± 0.03**

N

N[1] = Number of observations;

[2] =Probability values of fixed factors

[abcde] =Subclass means bearing common superscripts in the same column are not significantly different (p>0.05).

4.3.3 Effect of stage of lactation

Apart from cholesterol levels in milk which was affected ($p<0.05$), stage of lactation had little influence ($p>0.05$) on fresh milk's protein, fat, lactose, SNF and total solids in this on-farm study. Cholesterol levels reduced with increasing stage of lactation.

4.3.4 Effect of different seasons

Season influenced ($p<0.01$) all fresh milk component traits except cholesterol levels which were not affected ($p>0.05$) (Table 4.3). It was observed that milk protein was low ($p<0.01$) in major rain but increased in minor and dry seasons. Solid-non-fat content followed a similar trend as observed in percentage protein component.

Fat was highest ($p<0.01$) in milk during the major season and decreased in the minor and dry seasons. Similar trends were observed in lactose and total solids components. Similar ($p>0.05$) cholesterol levels were observed in all seasons.

4.4 Interaction effects of fixed factors on percentage components

Table 4.4 shows interaction effects of fixed factors on traits. Two-way interaction effect of breed x parity was significant in percentage protein ($p<0.05$) and lactose ($p<0.01$). Significant interaction of breed x SOL was observed in percentage fat ($p<0.05$) and lactose ($p<0.01$). Breed x SOS interaction was significant in percentage protein ($p<0.01$), lactose ($p<0.01$) and SNF ($p<0.05$). All other interaction effects were not significant ($p>0.05$).

Table 4.4: interaction effects of fixed factors on milk components

Type of interaction	% Protein	% Fat	% Lactose	% cholesterol	% SNF	% TS
Breed*Parity	*	ns	**	ns	ns	ns
Breed*SOL	ns	*	**	ns	ns	ns
Breed*SOS	**	ns	**	ns	*	ns
Parity*SOL	ns	ns	ns	ns	ns	ns
Parity* SOS	ns	ns	ns	ns	ns	ns
SOL*SOS	ns	ns	ns	ns	ns	ns

**=p<0.05; **=p<0.01; ns=not significant*
SOL=Stage of lactation; SOS=Seasons of sampling; SNF=Solids-non-fat; TS=Total solids

CHAPTER FIVE

5.0 DISCUSSION

5.1 Milk yield

The overall average milk yield (2.0 litres/cow/day) across breeds from partial milking is comparable to results reported by Annor (1996), and Millogo *et al*. (2008) (1.8, and 2.3 litres, respectively). It is, however, lower than that presented by Kamal *et al*. (2009) (3.8 litres) in local breeds in India.

The low milk yield in the present study gives an indication that majority of the smallholder cattle farmers manage their cows on sedentary, and/or traditional system where animals are exclusively kept on natural pasture (Millogo *et al*., 2008), leading to low production. This can be substantiated by the fact that only 13% of the farms studied provided regular feed supplementation to cows. In addition, the total milk produced by these cows is shared between the calves and herdsmen (Oppong-Anane, 1999; Millogo, 2010). This makes it difficult to account for the actual milk yield of the local breeds in West Africa (Millogo, 2010).

5.1.1 Effect of location on average milk yield

Different locations (districts) having different milk yield corresponds with the trend of results reported by Rege *at al*. (2001). These variations in average milk yield are characteristic of different geographical location with respect to quality and quantity of forage available (Ngongoni *et al.,* 2006), management, plane of nutrition and dominant breed reared (Rege *et al*., 2001; Millogo, 2010). Atwima Nwabiagya and Ejisu-Juaben are located in the wet semi-equitorial zone, whereas Sekyere South is located in moist semi-deciduous zone and Ejura-Sekyedumase is in the transitional zone (Ghana

Districts, 2006). These vegetational zones produce different quality and quantity of grasses that affect cows' performances.

5.1.2 Effect of breed

Sokoto Gudali crossbred recorded the highest average milk yield, but this was lower than the 5.3 kg/litres reported for the same breed (Aboagye, 2002). The current findings on WASH and Sanga fall within the ranges of 1.1 to 2.6 and 0.87 to 2.1 reported by Annor (1996) and Aboagye (2002), respectively.

The observed differences in milk yield among breeds might be due to their genetic potential and environmental effects (Aboagye, 2002) with regard to milk production. According to Annor (1996) crossing of low milk production potential breeds (e.g. WASH and N'dama) with the high milk production ones (e.g. Jersey and Zebu) leads to a dramatic improvement in the quantity of milk yield, presumably due to heterosis and breed complementarity (Lopez-Villalobos and Garrick, 2002).

5.1.3 Effect of parity of cow

The result obtained for the effect of parity on milk yield is consistent with the trend of the findings reported by Epaphras *et al.* (2004) and Darfour-Oduro *et al*. (2010) in local cattle, and Afzal *et al.* (2007) in sheep. Holmes *et al.* (1984) and Bhuiyan *et al.* (2004) stated that at parity 1, the udder and teat structural growth have not yet fully developed to assume their peak functions. Cows' udder and teat development increases with increasing parity. Good udder and teat anatomy and milk flow rate are positively correlated with the daily milk yield (Holmes *et al*., 1984; Bardakcioglu *et al*., 2011; Deng *et al*., 2012).

5.1.4 Effect of season of lactation

The highest milk yield was recorded in the major rainy season, followed by the minor rains, with the dry season recording the least. This observation agrees with the findings of Epaphras *et al.* (2004) and Hatungumukama *et al*. (2006). This can be explained by the availability and good quality of pasture. In the dryer and hotter periods, as a result of feed inadequacy and low nutritive value (Table 3.1) of the natural pastures, milk yield tends to be low (Epaphras *et al*., 2004)

5.1.5 Effect of udder and teat sizes

Udder size may not be a fair determinant of milk yield since it had little or no influence on milk yield. However, teat size may be a good determinant of milk yield. This observation was also made by Kukovics *et al*. (2006) and Bardakcioglu *et al*. (2011). Holmes *et al*. (1984) stated that large teat size facilitates the ease at which milking is done manually or mechanically.

5.1.6 Effect of feed supplementation

Similar results of the effect of feed supplementation on milk yield were observed in local cattle and local x exotic crosses in Ghana (Annor, 1996), Burkina Faso (Millogo *et al.,* 2008) and Bangladesh (Kamal *et al*., 2009). Nutrition is an important environmental factor that is very crucial in animals' productive performances and health. According to FAO (2013), adequate nourishment through supplementation provides benefits in twofold: less health issues (i.e., builds cows immunity), and more milk production combined with equal or even lower rearing costs. Better daily yields exhibited by cows supplemented with feed might be attributed to the enhancement in nutrients that would during the lean seasons and also improvement of utilization, as it was also observed by Epaphras *et al.* (2004) and M'hamdi *et al*. (2012).

5.1.7 Effect of body condition on average milk yield

Differences realized in average milk production with respect to different BCS suggest that lower BCS (≤2) and extremely high BCS may not be recommended for profitable dairying. It can be noticed that very few cows (2.5%) were in the BCS 5 perhaps due to reproductive problem (e.g. impaired reproductive efficiency) associated with these cows. This buttresses the findings of many researchers who recommend that a cow entering the dry period should have a BCS between 3.25 and 3.75 points for better performance (Gumen *et al*., 2003; Lopez *et al*., 2005; Watters *et al.*, 2010; Gergovska *et al*., 2011). It is also clear that cows without adequate body reserves and/or those with excessively high BCS are prone to diseases (e.g. fat cow syndrome or fatty liver disease), metabolic disorders, and reduced milk yield (Patton *et al*., 1988; Loker *et al*., 2010).

5.2 Lactation length of dual-purpose cattle

The overall average lactation length (LL) (246.4 days) recorded in this study across breeds is similar to the mean of 248 days stated by Bajwa *et al*. (2004) in Pakistan, and falls within ranges reported by Aboagye (2002), and Kugonza *et al*. (2011) in local breeds in Africa on-station. It is however higher than the mean LL reported by Darfour-Oduro *et al*. (2010) for Sanga (164.1 days) and Friesian-Sanga (201.1 days) cows in Ghana, but far lower than averages of 305, 305, and 327 days observed for Friesian-WASH, Jersey-Gudali and Friesian-Gudali crosses respectively in Ghana (Annor, 1996).

The differences observed may be attributed to varied genetic merits in terms of milk production performances of the various breeds. The crossbred cows might have inherited longer lactation periods from Zebu or foreign breeds in addition to the local breeds' adaptability to humid climate. This might have been achieved presumably through heterosis and breed complementarity (Aboagye, 2002; Lopez-Villalobos and Garrick, 2002). Whilst breed complementarity involves the additive combination of adaptation of the tropical breed with the productivity of the improved exotic breed, heterotic effects are accounted for by dominance and epistatic gene effects which are non-additive (Aboagye, 2002).

5.2.1 Effect of location on lactation length

The results obtained for the effect of location on LL is an indication that management practices such as feeding, routine disease control and feed supplementation are similar in the various Districts (Ngongoni *et al.,* 2006). These environmental factors might have masked the dominant breed effects at different locations, otherwise there could have been some effect.

5.2.2 Effect of breed

Mean LL for Sokoto Gudali, White Fulani, Sanga-Gudali, Sanga, WASH, and N'dama cows observed in this study are comparable to on-station average values of 244.8 and 220.0 days reported for Sokoto Gudali and White Fulani, respectively (Tawah and Rege, 1996) and 220.0 for Sanga (Okantah, 1992). The observed values are however, lower than LL reported for N'dama (283.0 days) (ILRI, 2009) and exotic breeds (300.0 days) (Oppong-Anane, 2013). Lactation period for WASH (Table 4.2) falls within the on-station range of 29-261 days (Aboagye, 2002). The least LL of WASH in this study can be explained by their inability to let down milk in the absence of their calves coupled with their lower milk yield potential (Aboagye *et al.,* 1994; Aboagye, 2002).

The differences in LL between the Zebu and their crosses on one hand and WASH on the other hand might have resulted from the genetic superiority of the Zebu and their crosses over the indigenous WASH (Bajwa *et al*., 2004; Afzal *et al*., 2007; and Darfour-Oduro *et al*., 2010). The WASH is known to have poor milk attributes. Evidence to this effect is the recorded lowest total milk yield of 44 kg/lactation in 29 days lactation period reported by Aboagye (2002).

5.2.3 Effect of sex of calf and season of calving

Similar findings of the effect of sex in this study were reported by Afzal *et al*. (2007). The finding in season of calving contradicts that obtained by Bajwa *et al.* (2004) and M'hamdi *et al*. (2012). They observed that cows calving in the rainy season had longer ($p<0.01$) LL than those calving in the dry season. The similar performance in LL among cows in different seasons in this study may be due to feed supplements provided to about one-half of the cows which might have offset the harsh seasonal effect that results from imbalance of feed (Dunn and Moss, 1992; Osuagwuh, 1992; Sibanda *et al.,* 1997).

5.2.4 Effect of parity

Parity did not influence LL. This finding is similar to that reported by Afzal *et al*. (2007) and M'hamdi *et al*. (2012). However, Epaphras *et al.* (2004), Dillon (2006), Darfour-Oduro *et al*. (2010) and Watters *et al.* (2010) reported that parity has influence on LL. They observed that LL increases with increasing parity. These disparities may be due to different parity levels used in the various studies.

5.2.5 Effect of feed supplementation

It is worth noting that feed supplementation is one of the environmental factors which can mask genetic potential for production. It is not surprising to realise longer lactation duration for cows that were given regular and occasional supplementations than those provided with no supplement. This result is comparable to the findings of Epaphras *et al.* (2004) and M'hamdi *et al.* (2012). The yields of farm animals are the result of the combined effects of genotype and environmental conditions which include nutrition and all other management routines (Afzal *et al*., 2007; and Darfour-Oduro *et al*., 2010). Feed supplementation of lactating cows substantiates inadequate nutrients in feed or fodder in the lean seasons and thereby increases daily milk yield and LL. According to Looper (2012) and M'hamdi *et al*. (2012), provision of good feeding level (3.5 to 4.0 percent of their body weight daily as dry matter) for dairy cows boosts up lactation performance.

5.2.6 Effect of body condition score

In this study body condition score (BCS) was found to be one of the determinants of LL. This outcome is comparable to the findings of Watters *et al.* (2010), and Gergovska *et al.* (2011). High mean lactation duration at calving recorded in descending order for BCS 4, 3, and 2 (Table 4.2) is an indication that the higher the BCS at calving the longer the LL. This may be due to the fact that, increase in feed intake in early lactation is not adequate to meet energy requirement of milk production, and therefore lactating cows resort to mobilization of their body reserves which cause them to lose BCS. Similar observation was made in Holstein-Friesian and it is considered a normal physiological state for cows in early lactation (Loker *et al*., 2010).

Cows which lose more than one score of their body condition are likely to be predisposed to early ovulation which when fertilised shortens lactation length (Watters *et al*., 2010). This may be applicable to cows with BCS of ≥ 3, since unitary loss of body condition of ≤ 2 would adversely affect ovulation, and in lactating cows LL resulting from inadequate body reserves to support lengthy lactation may occur. Similar observations have been made by Samarutel *et al.* (2006) and the indication is that cows with lower body condition score at calving cannot achieve their genetic milk yield potentials and days in milk due to lack of body reserves that may support increasing milk yield at the beginning of lactation. The lowest LL recorded by cows with BCS 2 may be attributed be to these facts. Gergovska *et al*. (2011) also noted that milk yield and lactation period of cows with low body condition score (≤2.5 scores) have 1400 kg lower and shorter LL than that of cows with BCS greater than 3.5 points.

Cows with BCS 3 had better lactation length (Table 4.2) and unitary loss in body condition may not adversely affect their performances. Indeed, cows with BCS 4 recorded the best LL because they might have utilised most of their body reserves in early lactation for relatively lengthy lactation period. Similar findings by Gergovska *et al*. (2011) indicated that Friesian and Brown Swiss cows that lost more body condition had highest milk yield at optimal lactation duration. It is common for a dairy cow to lose more than one BCS, therefore ensuring that a cow does not lose more than one score is important because of the increased chances of the cow experiencing anovular—absence of ovulation (Watters *et al*., 2010). A herd of cattle in good body condition

(BCS ≥3) will produce more milk in longer LL, and will be less susceptible to metabolic disorders, disease, mastitis and reproductive problems (Patton *et al*., 1988). The two extremes BCS 1 and 5 had no records in the current study presumably due to health issues as reported by Keown (2005) that under-conditioned cows are subject to health problems, whilst over-conditioned cows are prone to calving difficulties, fatty liver syndrome and possible death. The current findings therefore suggest that the optimum range of BCS for lengthy LL lies between ≥3 to ≤ 4. It can also be asserted that BCS of 3 to 4 of the dual-purpose cows have enough body reserves for longer lactation length.

5.3 Milk composition

5.3.1 Effect of breed on milk components

Average percentage components of milk protein recorded for Gudali, N'dama, Sanga, Sanga-Gudali cows, WASH, and White Fulani (Table 4.3) are far higher than averages of 3.1 or 3.9, 3.4 and 3.8 % reported for Zebu, WASH and exotic breeds respectively (O'Connor, 1995; Annor, 1996; Aboagye, 2002). They are also higher than the percentage range of 1.57 to 4.66 % stated by Heinrichs *et al*. (2005).

The higher percentage protein component in fresh milk in this study can be assigned to higher nutrient levels with relatively minimal fibre content in feed as realised in the proximate fractions in dominant forage fodder in the region as indicated in Table 3.1. Most of the studies reported above in the literature emanated from coastal and Sudan savanna areas where the nutritive value of grasses is lower than those in forest areas. Kumaresan *et al.* (2008) and Looper (2012) stated that cows' milk protein increased with increasing feed intake and frequency, high non-fibre carbohydrates and crude protein.

The considerable variations among breeds' milk protein component might be attributed to the individual breed potentials, although environmental effects (management, feeding, and disease condition e.g. mastitis) can play an influential role in modifying milk components. This is in agreement with the assertion made by Varga and Ishler (2010) that besides breed, nutrition and blood amino acids (primary precursor of milk protein), microbial amino acids are easily and efficiently converted into milk protein by the cow. Therefore, selection for breeding on the basis of individual performance is effective in improving milk compositional quality since heritability (h^2) estimate for milk protein component is 0.51 (O'Connor, 1995; Heinrichs *et al*., 2005).

Fat components of Sokoto Gudali, N'dama, Sanga, Sanga-Gudali cross, WASH, and White Fulani fall within the ranges of 1.77 to 5.98 % (Heinrichs *et al.,* 2005). The percentage component of fats of these breeds are however lower than the on-station averages reported by Okantah (1992) and Rege *et al*. (1994b). WASH had higher fat in this study than 1.3 % stated (Aboagye, 2002) but also lower than 4.1 reported by Rege *et al*. (1994b). Lower level of percentage fat in on-farm dual-purpose cows' milk may be due to trekking for longer distances for feed which might involve great energy expenditure that might have tolled on their fat reserves. This can also be attributed to inadequate feed supplementations that are balanced between energy and protein. Looper (2012) noticed that underfeeding of energy and high non-fibre carbohydrate (NFC) decrease milk fat content.

All things being equal, differences among individual breeds of cattle for milk fat, are due to their individual genotype, despite fat sensitivity to nutrition, intensity of lactation and stage of calving (Fox and McSweeney, 1998; Simões *et al.*, 2014).

On the basis of its merits (e.g. for butter making), selection can be made toward increasing fat component since its h^2 estimate is 0.50 (Varga and Ishler, 2010). On the other hand, the lowest fat components of WASH, Sokoto Gudali and Sanga-Gudali crossbred milk can be recommended for patients with the risk of cardiovascular disease (Lerenzen and Astrup, 2011), as a means of weight maintenance (Dougkas *et al*., 2011), and for lower risk of diabetes (Fumeron *et al*., 2011).

White Fulani, Sokoto Gudali, N'dama, and Sanga have higher cholesterol contents (Table 4.3) in their fresh milk than 0.56 and 0.59 % reported by Strzałkowska *et al*. (2009) and Strzałkowska *et al*. (2010). The average values of cholesterol levels of Sanga-Gudali crossbred and WASH (Table 4.3) are comparable to those reported in literature (Paura *et al*., 2003; Strzałkowska *et al*., 2009; Strzałkowska *et al*., 2010).

The differences in milk cholesterol levels might be due to genetic and environmental factors (e.g. management, nutrition e.t.c.) (Strzałkowska *et al*., 2010) which can influence physiological condition and subsequently affect cows' milk cholesterol content (Polat and Cetin, 2001). In general, the cholesterol content in milk of high yielding cows fed a uniform diet throughout the year has higher percentage cholesterol (Paura *et al*., 2003; Strzałkowska *et al*., 2010).

Percentage lactose recorded in this study (Table 4.3) are higher than 4.6 and 4.8 % for Zebu and Shorthorn respectively (O'Connor, 1995); 4.8 % in sheep and Water buffalo (Fox and McSweeney, 1998; Enb *et al*. (2009), and 4.6 -5.6 % in buffalo's milk (Ahmad *et al*., 2013). However, the percentage lactose in the present study is comparable to 6.2 in horse, and 7.0 in human and Chimpanzee (Fox and McSweeney, 1998).

The differences observed in the present study and that in literature may be due to extremely high nutritive value of forages in forest areas where the study was conducted. This is related to the findings reported by Varga and Ishler (2010) that changes in milk components are due to modifications in both the types of feed available and climatic conditions. The disparities in lactose contents among the different breeds of cows may also be as result of breed potentials and within breed variations (Fox and McSweeney, 1998); Heinrichs *et al*., 2005; Varga and Ishler, 2010; Ahmad *et al*., 2013).

Simililar findings obtained from percentage solids-non-fat (SNF) component of breed, parity, and stage of lactation agree with the report made by Kumaresan *et al.* (2008) that SNF is more vulnerable to environmental temperature than breed. The environmental temperature may also influence season of the year. This is true in that season has great ($p<0.01$) affinity in determining SNF levels in fresh milk.

Percentage component of total solids (TS) recorded for Sokoto Gudali, Sanga-Gudali crossbred, and WASH fall within the range of 10.5 to 14.5 % (O'Mahony, 1988). However, the TS contents of N'dama, Sanga, and White Fulani (Table4.3) are slightly higher than the upper limit of the reported range but these are far greater than the averages of 13.0 and 13.4 % reported by O'Mahony, (1988) and Enb *et al*. (2009). The TS values of these cows are also similar to the percentage TS reported for Zebu (14.7 %) and Jersey (15.0 %) (Jensen, 1995; O'Connor, 1995; Fox and McSweeney, 1998).

The variations in milk TS among different breeds studied are of no doubt due to the differences in individual breed as considered above. Heinrichs *et al*. (2005), Looper, (2012), and Schroeder (2012) alluded that although breed and inheritance contribute greatly (55%), 45 % of changes in milk component is influenced by environmental factors.

5.3.2 Effect of parity of cow

Based on this study, it can be asserted that parity may not be a good predictor of changes in milk composition. This finding is in support of the observation made by Strzałkowska *et al*. (2010) that milk component especially cholesterol is not affected by parity. The slight difference of 0.4 % drop in milk protein from parity 1 to 5 observed in this result, though insignificant, is higher than 0.10 to 0.15 unit decrease over a period of five or more lactations (Looper, 2012).

5.3.3 Effect of stage of lactation

Stage of lactation, apart from cholesterol levels, had little effect on other milk components. This finding contradicts the result of Heinrichs *et al*. (2005), Strzałkowska *et al*. (2010), Looper (2012) and Simões *et al.* (2014) who unanimously reported that the concentration of milk fat and protein are highest in early and late lactation and lowest during peak milk production through mid-lactation. These differences can be attributed to the ranges of groupings used for the stages of lactation in this study without a particular emphasis on early, mid and late lactations. O'Connor (1995), and Heinrichs *et al*. (2005) noted that at 0-3 and 30-55 weeks of lactation, the concentration of milk solids are higher than 4- 25 week (mid lactation).

5.3.4 Effect of season of lactation

The protein and solid-non-fat components show different pattern in that their percentage compositions are relatively higher in the minor and dry season. This trend is similar to the findings reported by Heinrichs *et al*. (2005) and Kumaresan *et al*. (2008). They also noticed highest values of total solids and SNF (including protein) contents of Jersey milk during the coldest/winter months.

Fats content together with lactose, and total solids have their percentage components being higher in the major rains than minor and dry seasons. This is as a result of rich nutritive fodders which abound in their required quantities for grazing cattle (Ngongoni *et al*., 2006; Looper, 2012).

5.3.5 Interaction effects of breed and other factors on milk component traits

Significant interaction observed indicates that the ranking of factors do not hold when combined set of level of two factors are considered. In other words, when the same genotype develops different phenotypes (% protein or lactose component) in different environments (different stages of lactation, seasons, parities), then there is G x E interactions between the genotype and the environmental factor(s). Many researchers have reported important interaction effects when the same genotypes develop different phenotypes/milk production traits in different environments (Bryant *et al*., 2005; Hammami *et al*., 2009; Gebreyohannes *et al*., 2014). Gebreyohannes *et al*. (2014) observed dissimilarities in climate, management and feeding contributing to breed group differences in milk production performance at two locations due to genotype/breed x environment interactions (GEI).

This GEI might have arisen when the performance of the genotypes (Gudali, Sanga, e.t.c.) are not equally influenced by the different environments. In this study for instance, given different seasons: major rains, minor and dry seasons, % lactose component yield for Sanga-Gudali crossbred were 10.4, 4.0, 4.3 % respectively. Similar interactions were recorded for breed x parity, breed x SOL and breed x SOS on % protein, fat, and lactose. Change in the relative performance of two or more genotypes measured in two or more environments would therefore aid in improvement and evaluation of farm animal genetic programmes (Annor, 2011); and development of cattle production objectives (Hammami *et al*., 2009; Gebreyohannes *et al*., 2014). Therefore, breeders/producers could select genotypes on production traits within environmental conditions comparable to where candidate animals are intended to perform.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 *Effect of breed and non-genetic factors on average milk yield*

- Farm location, breed, parity, season of lactation, teat size and feed supplementation had significant influence on average milk yield, whereas udder size had little effect.
- Zebus (Sokoto Gudali and White Fulani) and their crosses had better average milk yield than Taurine breeds (N'dama and WASH).
- Provision of supplementary feed to dual purpose cows resulted in increased average milk yield.
- Average milk yield increased with increasing parity up to sixth parity and declined afterwards.
- Milk yield was low in the dry season but it increases with increasing onset of the rainy seasons.
- Increasing teat size led to increase in milk yield.
- Lower BCS (≤ 2) and extremely high BCS led to reduced milk yield

6.1.2 *Effect of breed and non-genetic factors on lactation length*

- Breed, feed supplementation and body condition score had great influence on LL whilst location, season, parity and sex of calf had little effect.
- Sokoto Gudali and their crosses, Sanga, and N'dama breeds had promising LL.
- Feed supplementation prolonged LL.
- Cows in good body condition had prolonged LL.

6.1.3 Effect of breed and non-genetic factors on percentage milk composition

- Breed and season had large influence on percentatage milk compositions/components studied except solid-non-fat.
- Parity and stage of lactation had little effects on percentage components of fresh milk, however, the latter influenced cholesterol levels.
- Interaction effects of breed, stage of lactation and season were significant in percentage protein, fat, lactose and solid-non-fat components of dual-purpose cows.

6.2 Recommendations

- Recommendations made from the study on average values of milk yield of the dual-purpose cows are that:
  - Lactating cows should be provided with supplementary feed in the minor and dry seasons to increase milk yield.
  - Cows showing signs of reduced milk yield after the sixth parity should be culled and replaced for higher economic returns.
  - Lactating cows should be conditioned to be in moderate to high BCS.
  - In selection of young heifers for milk production, teat size should be considered.
  - Milk production can also be based on Zebus and their crosses with taurine cattle

- The study on Lactation length (LL) of dual-purpose cows recommended that:
  - The Zebus and their crosses are better candidates for prolonged milk production per lactation.
  - Breeds of dual purpose cattle with promising lactation lengths should be considered in LL improvement programmes.

- Lactating cows should be provided with feed supplementation to prolong LL. This would also further improve their body condition to increase LL.

- Recommendations made from the study on percentage milk composition of the breeds of dual purpose cows are that:
  - Breed should be considered by producers on the basis of milk production merits; e.g. those interested in butter production could select breed with higher % fat.
  - Breed x environmental interactions are crucial, therefore, breeders/producers could select genotypes on production traits within environmental conditions comparable to where candidate animals are intended to perform better.

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APPENDIX

Publications from dissertation:

Proceedings GSAP 2013 Conference *Coffie et al., 2013*

EFFECT OF BREED AND NON-GENETIC FACTORS ON MILK YIELD OF DUAL-PURPOSE CATTLE IN ASHANTI REGION

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ABSTRACT

The objective of this study was to determine the effect of breed, parity, season of lactation, udder and teat sizes, and feed supplementation on milk yield of dual-purpose cattle in four districts of the Ashanti Region. A total of 267 cows kept under farmers' own management that calved and lactated were involved. Milk yield was measured in litres per cow for three times at four weeks interval in three seasons. All the fixed factors, except udder size influenced ($p<0.01$) milk yield. Average daily milk yield per cow across breeds was 2.2 litres. Average daily milk yield per cow for West African Shorthorn, Sanga, White Fulani, Sokoto Gudali and Sanga-Gudali crossbred were 1.9, 2.1, 2.1, 2.7 and 3.1 litres ($p<0.01$), respectively. Milk yield increased with increasing parity and started dropping in the seventh parity. Average daily milk yield for small, medium and large teat size were 2.0, 2.5, and 2.7 litres ($p<0.01$), respectively. Average daily milk yield per cow receiving regular and occasional feed supplementation, and no feed supplementation were 2.8, 2.2, and 2.1 litres ($p<0.01$), respectively. It was concluded that regular feed supplementation is one of the surest way of maximizing milk yield. Sanga and Gudali/White Fulani crossbred cattle could be used for the dual-purpose dairying in Ashanti Region, and cows with reduced milk yield after the 6th parity should be replaced for higher economic returns.

Keywords: parity, Sanga, season of lactation, Sokoto Gudali**,** West African Shorthorn, White Fulani

INTRODUCTION

In many West African countries, dairy production is extremely low (CAADP, 2010). Estimates for Ghana are around 36,000 MT per annum (corresponding to only about 30% of the local milk consumed in the country), compared to local production of 244,000 MT in Burkina Faso (55% of local consumption) and 146,000 MT in Senegal (30-35% of local consumption) (CAADP, 2010). This may be due to low genetic potential of local cattle and other non-genetic factors (Hatungumukama *et al.,* 2006 and Pagot, 1992). In Ghana, exotic breeds especially Friesian, Jersey and their crosses cannot withstand climatic/environmental test and thereby suffer from dermatophilosis and heartwater crosses(Koney, 1996). There is a suggestion that milk production in Ghana must be based on of the Zebu and selected West African Shorthorn Cattle and Sanga (MOFA, 2004),

A lot of studies have been done on the effects of non-genetic factors on the milk yield of exotic cattle in Ashanti Region (Kabuga and Agyemang, 1983; Osei *et al.* 1991) but little has been done on the effect of non genetic factors on local cattle and their crosses.

The objective of this study was to determine the effect of breed, parity, season of lactation, udder and teat sizes, and feed supplementation on milk yield of dual purpose cattle.

MATERIALS AND METHODS

The study was conducted in four Districts of Ashanti Region from June 2012 to April 2013. The Ashanti Region is centrally located in the middle belt of Ghana. It lies between longitudes 0° 9'W and 2° 15'W, and latitudes 5° 30'N and 7° 27'N. The region has a population density of 148.1 persons per square kilometre, and ranks third after Greater Accra and Central Regions (Ghana Districts, 2006). More than half of the region lies within the wet, semi-equatorial forest zone. Bushfires during the dry season has reduced the forest vegetation of parts of the region, to savannah, particularly the north-eastern portion. The region has an average annual rainfall of 1270 mm and two rainy seasons. The major rainy season starts from April to July. The minor rains occur in August to November. December to March is dry, hot, and dusty. The average daily temperature is about 27^{o}C (Ghana Districts, 2006).

A total of 267 dual purpose cattle were purposively selected from 17 farms within 4 Districts (Atwima-Nwabiagya, Ejisu-Juaben, Sekyere South and Ejura-Sekyedumasi) in Ashanti Region, based on availability of lactating dual purpose cows. The breeds of cattle used for the study include WASH (n=32), Sanga (n=102), White Fulani (n=117), Sokoto Gudali (n=12) and Sanga-Gudali crossbreed (n=4).

Animals were reared under farmers' own management with or without feed supplementation. These animals were kept in kraals after daily routine grazing of about 7 hours (9:30am to 4:30pm) per day. The common forage species grazed in the rangeland included elephant grass (*Pennisetum purpureum*), guinea grass (*Panicum maximu)* and Centro (*Centrocaema pubescence)*. Three farms provided regular feed supplementation for morning and evening with available crop residues and agro-by-products; two farms provided occasional feed supplementation as and when crop residues/by-products were available, and twelve did not provide any feed supplementation. Animals were de-wormed with Albendazole 10% at three month interval. Records were not taken from sick animals undergoing treatment.

Each animal record included, district of origin, breed, parity, season of lactation, udder size, teat size, type of feed supplementation and milk yield**.** Milk yield was measured (once a day in the morning) in litres for three times at four weeks interval in each of the three seasons (major and minor rains, and dry seasons) using a 500 ml (0.5litre) graduated infusion rubber bottle and funnel. Hand milking was used. Udder base circumference [UBC] and length [UL] from base of udder to the base of teat were measured and categorized into small (UBC≤69cm; UL ≤12cm), medium (UBC=70-80cm; UL=13-16cm) and large (UBC >80cm; UL≥17cm). Teat base circumference (TBC) and its length [TL] were measured and considered as small (TBC≤5cm; TL≤ 2cm), medium (TBC=6-8cm; TL=2.5-5cm) and large (TBC≥9cm; TL>5cm).

Data gathered were subjected to least squares analysis using Generalized Linear Models (GLM) Type III procedure of SAS (SAS, 2008) on the following fixed model.

$Y_{ijklmnop} = \mu + D_i + B_j + P_k + S_l + U_m + T_n + X_o + e_{ijklmnop}$, Where:

$Y_{ijklmnop}$ = the dependent variable or milk yield; μ = the population mean; D_i = the effect of the i^{th} District, i = 1, 2, 3, 4; B_j = the effect of the j^{th} breed, j = 1, 2, …, 5; P_k = the effect of k^{th} parity of cow, k = 1, 2, …, 7; S_l = the effect if l^{th} season of lactation, l = 1, 2, 3; U_m = the effect of m^{th} udder size, m = 1, 2, 3; T_n = the effect of the n^{th} teat size, n = 1, 2. 3; X_o = the effect of o^{th} supplementation, o = 1, 2, 3; and $e_{ijklmnop}$ = the error term.

Two- and three-way interactions among fixed variables were not significant and therefore ignored.

RESULT AND DISCUSSION

Overall milk yield

The effects of all fixed factors studied on milk yield are shown in Table 1. The overall average milk yield per cow per day across breeds obtained was 2.2 litres (Table 1). The value is comparable to those reported by Annor (1996), and Millogo *et al*. (2008) (1.8, and 2.3 litres respectively) but is lower than that presented by Kamal *et al*. (2009) (3.8 litres) in local breeds.

Table 1: Least square means and standard errors for the effects of fixed factors on milk yield

Fixed factors	Number of Animals	Average Milk yield (litters/cow/day)
DISTRICT		***P = 0.0058*** [1]
Ejura Sekyedumase	97	2.7 ± 0.14^{a}
Sekyere South	125	2.5 ± 0.13^{ab}
Ejusu Juabimg	23	2.2 ± 0.19^{bc}
Atwima Nwabiagya	22	2.1 ± 0.20^{c}
BREED		***P= 0.0005*** [1]
Sanga X Gudali	4	3.1 ± 0.32^{a}
Sokoto Gudali	11	2.7 ± 0.23^{a}
Sanga	102	2.1 ± 0.13^{b}
WASH[2]	33	1.9 ± 0.15^{c}
White Fulani	117	2.1 ± 0.12^{b}
PARITY		***P = 0.0014*** [1]
1	48	2.2 ± 0.13^{a}

2	64	2.5 ± 0.11[b]
3	60	2.7 ± 0.11[b]
4	52	2.5 ± 0.12[b]
5	22	2.5 ± 0.16[b]
6	12	2.6 ± 0.19[b]
7	7	1.9 ± 0.25[a]
SEASON OF LACTATION		***P = < 0.0001***[1]
Major rains	37	3.0 ± 0.17[a]
Minor rains	139	2.3 ± 0.13[b]
Dry season	91	1.8 ± 0.14[c]
UDDER SIZE		***P = 0.3492***[1]
Small	13	2.3 ± 0.20
Medium	149	2.4 ± 0.12
Large	105	2.5 ± 0.13
TEAT SIZE		***P = < 0.0001***[1]
Small/rudimentary	40	2.0 ± 0.15[a]
Medium	136	2.5 ± 0.13[b]
Large	91	2.7 ± 0.14[c]
SUPPLEMENTATION		***P = < 0.0001***[1]
Regular	43	2.8 ± 0.15[a]
Occasional	53	2.2 ± 0.14[b]
No supplementation	167	2.1 ± 0.13[bc]
OVERALL	**267**	**2.2 ± 0.03**

[1]*P value = probability of main effects*

[2]*WASH= West Africa shorthorn*

The low yield gives an indication that majority of the smallholder cattle farmers manage their cows on sedentary, and/or traditional system where animals are exclusively kept on natural pasture (Millogo *et al*., 2008). This is true because only 29% of the farms studied provided feed supplementation to cows.

Effect of District on a milk yield

District had influence (p<0.01) on milk yield (Table 1). Ejura Sekyedumase District recorded the highest average milk yield, followed by Sekyere South, Ejisu Juaben and Atwima Nwabiagya in descending order. This corresponds with the trend of results reported by Rege *at al*. (2001). These variations in average yield are characteristics of different geographical location with respect to quality and quantity of forage available (Ngongoni *et al.,* 2006), management, plane of nutrition and breeds (Rege *et al*., 2001; Millogo, 2010).

Effect of breed on average milk yield

There were breed differences (p< 0.01) in average milk yield (Table 1). Sanga-Gudali crossbred recorded the highest average milk yield, with the Sokoto Gudali, White Fulani, Sanga, and WASH following in that order. According to Annor (1996) crossing of low milk production potential breeds (e.g. WASH and N'dama) with the high milk production ones (e.g. Jersey and Zebu) leads to a dramatic improvement in the quantity of milk yield, due to heterosis and breed complementarities (Lopez-Villalobos and Garrick, 2002).

Effect of parity on average milk yield

Parity of birth had a great influence ($p<0.01$) on average milk yield. Milk yield at the first parity was relatively low (Table 4.3). Thereafter, average milk yield assumed a sustained increase from second to sixth parities and then sharply declined at the seventh parity. This is consistent with the trend of the findings reported by Epaphras *et al.* (2004), and Darfour-Oduro *et al*. (2010) in local breeds. Holmes *et al.* (1984) stated that at parity 1 the udder and teat structural growth have not yet fully developed to assume their peak function. Cows' udder and teat development increases with increasing parity. Good udder and teat anatomy and milk flow rate have positively corresponded with the daily milk yield (Holmes *et al.*, 1984)

Effect of season of lactation on average milk yield

Season of lactation had large effect ($p< 0.01$) on average milk yield (Table 1). The highest milk yield was recorded in the major rainy season, followed by the minor rains, with the dry season recording the least. This observation agrees with the finding of Epaphras *et al.* (2004) and Hatungumukama *et al.* (2006). This can be explained by the availability and quality of pasture. In the dryer and hotter periods, as a result of feed inadequacy and low nutritive value of the natural pastures, milk yield tend to be low (Epaphras *et al*., 2004)

Effect of udder and teat sizes on average milk yield

Udder size had little ($p>0.05$) effect on milk yield. However, milk yield increased with increasing teat size ($p< 0.01$) (Table 1). This observation was also made by Kukovics *et al.* (2006). Holmes *et al*. (1984) stated that large teat size facilitates the ease at which milking is done manually or mechanically.

Effect of supplementation on average milk yield

Regular feed supplementation gave the highest ($p<0.01$) milk yield. Occasional and no feed supplementation gave similar ($p>0.05$) yield. Similar results were observed in local cattle and local x exotic crosses in Ghana (Annor, 1996), Burkina Faso (Millogo *et al*., 2008) and Bangladesh (Kamal *et al*., 2009). FAO (2013) indicates that, adequate nourishment through supplementation provides benefits in twofold: less health issues (i.e., builds cows immunity), and more milk production combined with equal or even lower rearing costs.

CONCLUSION AND RECOMMENDATIONS

- Farm location, breed, parity, season of lactation, teat size and feed supplementation had very large influence on average milk yield, whereas udder size had little effect.
- Sanga and Sokoto Gudali crossbred could be used for dual-purpose dairying in Ashanti Region.

- Cows showing signs of reduced milk yield after the 6th parity should be culled and replaced for higher economic returns.
- Lactating cows should be provided with supplementary feed in the minor rainy and dry seasons to increase milk yield.

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EFFECT OF BREED AND NON-GENETIC FACTORS ON LACTATION LENGTH OF DUAL-PURPOSE CATTLE IN ASHANTI REGION

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ABSTRACT
This study was conducted to determine the effect of genotype and non-genetic factors on lactation length (LL) of on-farm dual-purpose cows at smallholders' farms in Ashanti-Region. The dates of calving to the time of drying-off of milk in 124 cows were monitored from June 2012 to April 2013. Analysis of data indicated that breed, feed supplementation and body condition score (BCS) significantly ($p<0.01$) influenced LL. Average LL across breed was 246.4 days with minimum and maximum being 155 and 303 days, respectively. Mean LL for Sokoto Gudali, White Fulani, Sanga-Gudali cross, Sanga, West African Shorthorn (WASH) and N'dama were 278.1, 255.7, 262.5, 260.7, 214.5, and 261.2 days, respectively. West African Shorthorn had the least LL whilst similar ($p>0.05$) observations were made in all the other breeds. Cows that were provided with regular, occasional, and no feed supplementation recorded mean values of 265.7, 259.1 and 241.5 days ($p<0.01$), respectively. The least mean LL was observed in cows provided with no supplementation whilst regular and occasional supplemented cows had similar ($p>0.05$) LL. Lactation length of 270.7, 257.6 and 237.9 days ($p<0.01$) were recorded for BCS 4, 3, and 2, respectively. Thus, LL significantly increased ($p<0.01$) as body condition score increased. Farm location, season of lactation, parity of cow and sex of calf had little ($p>0.05$) effect on LL. It was concluded that breed had great influence on LL and could be considered when selecting dairy cows for breeding. Adequate feeding by way of providing feed supplementation is necessary to increase LL, and therefore milk production.

Key words: *body condition score, genotype, feed supplementation, milk production, parity, season of lactation, sex of calf, smallholder herd.*

INTRODUCTION
Lactation length (LL) and milk yield are two important traits of dairy animals which are influenced by genotype and environmental/non-genetic factors (Gergovska *et al*., 2011; Kugonza *et al*., 2011). Lactation length has positive influence on total milk yield per lactation (Bajwa *et al*., 2004; Endris *et al*., 2012) and therefore, profitability of the dairy industry (Lissow, 1999). Feed supplementation, parity of cow, sex of calf, and season of calving also have influence on LL (Bajwa *et al*., 2004; Darfour-Oduro *et al*., 2010). Several studies have been conducted on LL of some local, exotic breeds and their crosses on-station (Aboagye, 2002; Darfour-Oduro *et al*., 2010). Very little is however known about the factors affecting LL of the various dual-purpose cattle breeds of smallholder herds.

The objective of this study was to determine the effect of genotype and non-genetic factors on the LL of on-farm dual-purpose cattle at smallholders' farms in Ashanti-Region.

METHODOLOGY
The study was conducted in four Districts of Ashanti Region from June 2012 to April 2013. The Ashanti Region is centrally located in the middle belt of Ghana. It lies between longitudes 0° 9'W and 2° 15'W,

and latitudes 5° 30'N and 7° 27'N. The region has a population density of 148.1 persons per square kilometre, and ranks third in population size after Greater Accra and Central Regions (Ghana Districts, 2006). More than half of the region lies within the wet, semi-equatorial forest zone. Bushfires occur in the dry season, and has reduced the forest vegetation of parts of the region, to savannah, particularly the north-eastern portion. The detailed description of Ashanti Region's vegetation and seasons had been done in Coffie *et al.* (2013).

A total of 124 dual purpose cows of various breeds were purposively selected from 18 farms within 4 Districts (Atwima-Nwabiagya, Ejisu-Juaben, Sekyere South and Ejura-Sekyedumasi) in Ashanti Region in order to monitor their LL. The breeds of cattle used for the study included WASH (n=18), Sanga (n=43), White Fulani (n=25), Sokoto Gudali (n=12) Sanga-Gudali crossbreed (n=13) and N'dama (n=13).

Data on the date of calving, body condition score (BCS) at calving or the day of calving, parity cow, season of calving, location of calving and date of weaning were recorded. Weaning of calves were observed to be characterized by dams unwillingness to allow their calves to suckle, marked reduction in daily milk yield to less than 0.1 litre/day, calves reluctance to suckle, and in some breed loss of mothering abilities of cows and hostilely wild to herdsman. Lactation length was defined as the interval (days) between day of calving and weaning.

A five scale BCS used in this study (Patton *et al.,*1988; Keown, 2005) is defined as follows:

BCS 1
Rump Area: Deep cavity around tail-head. No fatty tissue felt between pins. Pelvic bone easily felt. Skin is supple.

Loin Area: Ends of short ribs sharp to touch. Upper surfaces can be felt easily. Deep depression in loin. Cows after having a severe DA are typically scored a 1.

BCS2
Rump Area: Shallow cavity lined with fatty tissue at tail-head. Some fatty tissue felt under pin bone. Pelvis easily felt.

Loin Area: Ends of short ribs feel rounded. Upper surface felt with slight pressure. Depression visible in loin.

BCS 3
Rump Area: No visible cavity around tail-head. Fatty tissue is easily felt over whole rump. Skin appears smooth. Pelvis is felt with slight pressure.

Loin Area: Ends of short ribs can be felt with pressure. There is a thick layer of tissue on top. There is only a slight depression in the loin.

BCS 4
Rump Area: Folds of fatty tissue are visible around tail-head. Patches of fat are present around the pin bones. Pelvis is felt only with firm

Loin Area: Short ribs cannot be felt even with firm pressure. No depression is visible in loin between backbone and hip bone.

BCS 5
Rump Area: Tail-head is buried in fatty tissue. Skin is distended. No part of pelvis can be felt even with firm pressure.

Loin Area: Folds of fatty tissue over short ribs. Bone structures cannot be felt. These cows are good candidates for fat cow syndrome.

Data on lactation length of the dual purpose cattle were subjected to least squares (LS) analysis using Generalized Linear Model (GLM) Type III procedure of SAS (SAS, 2008) on the following fixed model:

$$Y_{ijkmnqrt} = \mu + D_i + B_j + S_k + L_m + P_n + X_q + C_r + DB_{ij} + DS_{ik} + DL_{im} + DP_{in} + DX_{iq} + DC_{ir} + BS_{jk} + BL_{jm} + BP_{jn} + BX_{jq} + BC_{jr} + SL_{km} + SP_{kn} + SX_{kq} + SC_{kr} + LP_{mn} + LX_{mq} + LC_{mr} + PX_{nq} + PC_{nr} + XC_{qr} + e_{ijkmnqrt}$$; where,

$Y_{ijkmnqrt}$ = Lactation length; μ = population mean; D_i = the effect of i^{th} District/location, i =1, 2, 3, 4; B_j = the effect of j^{th} Breeds, j = 1, 2, …, 6; S_k = the effect of k^{th} sex of calf, k = 1, 2; L_m = the effect of m^{th} season, m 1, 2, 3; P_n = the effect of n^{th} parity, p= 1, 2, …, 5; X_q = the effect of q^{th} supplementation, q =1, 2, 3; C_r = the effect of r^{th} body condition, r = 1, 2, 3;
DB, DS, DL, DP, DX, DC, BS, BL, BP, BX, BC, SL, SP, SX, SC, LP, LX, LC, PX, PC , and XC = corresponding 2-way interactions; and $e_{ijkmnqrt}$ = the residual effect.

However, the 2-way interactions were not significant and therefore not considered.

Differences among means of significant effects were separated by the probability of difference (PDIFF) procedure of SAS (SAS, 2008).

RESULTS AND DISCUSSION

The overall mean of LL across breeds was 246.4 days with minimum and maximum values of 155 and 303 days, respectively (Table 1). This finding is comparable to 248 days reported by Bajwa *et al*. (2004) in Sahiwal cattle in Pakistan, and falls within ranges reported by Aboagye (2002) (29-261 days), and Kugonza *et al*. (2011) (165-255 days) on local breeds in Africa. It is however higher than the mean LL reported by Darfour-Oduro *et al*. (2010) for Sanga (164.1 days) and Friesian-Sanga (201.1 days) cows in Ghana, but far lower than averages of 305, 305, and 327 days observed for Friesian-WASH, Jersey-Gudali and Friesian-Gudali in Ghana (Annor, 1996).

The differences observed may be attributed to varied genetic merits in terms of milk production performances of the various individual breeds. The crossbred cows might have inherited the longer lactation periods from Zebu or foreign breeds in addition to the local breeds' adaptability to humid climate. This might have been achieved presumably through heterosis and breed complementarity. Similar finding was also reported by Aboagye (2002). Whilst breed complementarity involves the additive combination of adaptation of the tropical breed with the productivity of the improved exotic breed, heterotic effects are accounted for by dominance and epistatic gene effects which are non-additive (Aboagye, 2002).

Table 1: Least square means and standard errors for the effects of fixed factors on Lactation Length of the dual-purpose cows

Fixed factors	Number of observation	Lactation Length (days)
DISTRICT[1]		*0.4425*
Ejura Sekyedumase	24	253.6 ± 6.3
Sekyere South	50	251.2 ± 5.0

Ejusu Juabimg	15	255.8 ± 7.8
Atwima Nwabiagya	31	261.1 ± 5.9
BREEDS[1]		*0.0001*
Sokoto Gudali	12	278.1 ± 13.0[a]
White Fulani	25	255.7 ± 5.1 [a]
Sanga X Gudali	13	262.5 ± 11.2[a]
Sanga	43	260.7 ± 4.4[a]
WASH[2]	18	214.5 ± 6.9[b]
N'dama	13	261.2 ± 10.8[a]
SEX OF CALVES[1]		*0.3919*
Male	66	253.7 ± 4.8
Female	58	257.1 ± 5.0
SEASON[1]		*0.0963*
Major	52	262.8 ± 5.1
Minor	40	254.3 ± 6.2
Dry	32	249.1 ± 6.1
PARITY[1]		*0.0530*
1	51	250.4 ± 5.9
2	25	243.4 ± 5.8
3	25	254.1 ± 5.8
4	19	252.6 ± 6.4
5	4	276.5 ± 11.1
SUPPLEMENTATION[1]		*0.0004*
Regular	25	265.7 ± 6.5[a]
Occasional	37	259.1 ± 5.5[a]
No supplementation	62	241.5 ± 5.4[b]
CONDITION SCORE[1]		*0.0011*
BCS 2	35	237.9 ± 6.0[a]
BCS 3	65	257.6 ± 5.2[b]
BCS 4	24	270.7 ± 7.1[b]
Overall	**124**	**246.3 ±1.7**

[1] =Probability value of main effects

Effect of district

District had little or no influence (p>0.05) on LL (Table 1). This is an indication that management practices such as feeding, routine disease control and feed supplementation are similar in the various Districts studied, and similar findings have been reported by Ngongoni *et al.* (2006) in Zimbabwe.

Effect of breed

Breed effects on LL were significant (p<0.01). Mean LL for Sokoto Gudali, White Fulani, Sanga-Gudali, Sanga, WASH, and N'dama cows (Table 1) are comparable to on-station average values of 244.8 and 220.0 days reported for Sokoto Gudali and White Fulani, respectively (Tawah and Rege, 1996) and 220.0 for Sanga (Okantah, 1992). The observed values are however, lower than LL reported for N'dama (283.0 days) (ILRI, 2009) and exotic breeds (300.0 days) (Oppong-Anane, 2013). Lactation period for WASH (Table 1) falls within the on-station range of 29-261 days (Aboagye, 2002). The least LL of WASH in this study can be explained by their inability to let down milk in the absence of their calves coupled with their lower milk yield potential (Coffie *et al*., 2013).

The differences in LL between the Zebu and their crosses on one hand and WASH on the other hand might have resulted from the genetic superiority of the Zebu and their crosses over the indigenous WASH. This agrees with the findings of Bajwa *et al*. (2004), and Darfour-Oduro *et al*. (2010). The WASH is known to have poor milk attributes. Evidence to this effect is the recorded lowest total milk yield of 44kg/lactation in 29 days lactation period reported by Aboagye (2002).

Effect of sex of calf and season of calving

Sex of calf had little ($p>0.05$) effect on LL. Cows with female and male calves had similar LL (Table 1). Similar findings were reported by Afzal *et al*. (2007). Season of calving also had little ($p>0.05$) effect on LL. This finding contradicts that obtained by Bajwa *et al*. (2004) and M'hamdi *et al*. (2012). They observed that cows calving in the rainy season had longer LL than those calving in the dry season. The difference between the finding in this study and that of the other authors may be due to feed supplements provided to about one-half of the cows in this study, which might have offset the harsh seasonal effect that results from imbalance of feed (Sibanda *et al.,* 1997).

Effect of parity

Cows did not differ ($p>0.05$) in LL with respect to parity. Similar results were reported by Afzal *et al*. (2007) and M'hamdi *et al*. (2012). However, Epaphras *et al*. (2004), Darfour-Oduro *et al*. (2010) and Watters *et al*. (2010) reported that parity has influence on LL. They observed that LL increases with increasing parity. These disparities may be due to different parity levels used in the various studies.

Effect of feed supplementation

Supplementation of lactating cows significantly ($p<0.01$) influenced LL. It is not surprising to realise longer lactation duration for cows that were given regular and occasional supplementations than those provided with no supplement (Table 1). This result is comparable to findings of Epaphras *et al*. (2004) and M'hamdi *et al*. (2012). The yields of farm animals are the result of the combined effects of genotype and environmental conditions, the latter which include nutrition and all other management routines (Afzal *et al*., 2007; and Darfour-Oduro *et al*., 2010). Supplementation of lactating cows in this study seems to have substantiated inadequate nutrients in feed or fodder in the lean seasons thereby increasing daily milk yield and LL. According to M'hamdi *et al*. (2012) provision of good feeding level for dairy cows boosts up lactation performance.

Effect of body condition score

Body condition score (BCS) was found in this study to be one of the determinants of LL. This outcome is comparable to the findings of Watters *et al*. (2010), and Gergovska *et al*. (2011). High mean lactation duration at calving recorded in descending order for BCS 4, 3, and 2 (Table 1) is an indication that the higher the BCS at calving the longer the LL. This may be due to the fact that, in early lactation increase in feed intake is not adequate to meet energy requirement of milk production, and therefore lactating cows resort to mobilization of their body reserves which cause them to lose BCS. Similar observation was made in Holstein Friesian and it is considered a normal physiological state for cows in early lactation (Loker *et al*., 2010).

Cows which lose more than one score of their body condition are likely to be predisposed to early ovulation which when fertilised shortens lactation length (Watters *et al.*, 2010). This may be applicable to cows with BCS of ≥ 3, since unitary loss of body condition of ≤ 2 would adversely affect ovulation, and in lactating cows LL resulting from inadequate body reserves to support lengthy lactation may occur. Similar observations have been made by Samarutel *et al.* (2006) and the indication is that cows with lower body condition score at calving cannot achieve their genetic milk yield potentials and days in milk due to lack of body reserves that may support increasing milk yield at the beginning of lactation. The lowest LL recorded by cows in BCS 2 may be attributed be to these facts. Gergovska *et al.* (2011) also noted that milk yield and lactation period of cows with low body condition score (≤2.5 scores) have 1400 kg lower and shorter LL than that of cows with BCS greater than 3.5 points. Cows with BCS 3 had better lactation length (Table 1) and unitary loss in body condition may not adversely affect their performances. Indeed, cows in BCS 4 recorded the best LL because they might have utilised most of their body reserves in early lactation for relatively lengthy lactation period. Similar findings by Gergovska *et al.* (2011) indicated that Friesian and Brown Swiss cows that lost more body condition had highest milk yield at optimal lactation duration. It is common for a dairy cow to lose more than one BCS, therefore ensuring that a cow does not lose more than one score is important because of the increased chances of the cow being anovular—absence of ovulation (Watters *et al.*, 2010). A herd of cattle in good body condition (BCS ≥3) will produce more, and will be less susceptible to metabolic disorders, disease, mastitis and reproductive problems (Patton *et al.*, 1988). The two extremes BCS 1 and 5 had no records in the current study presumably due health issues as reported by Keown (2005) that under-conditioned cows are subject to health problems, whilst over-conditioned cows are prone to calving difficulties, fatty liver syndrome and possible death. The current findings therefore suggest that the optimum range of BCS for lengthy LL lie between ≥3 to ≤ 4. It can also be asserted that BCS of 3 to 4 of the dual-purpose cows have enough body reserves for lengthier lactation length.

CONCLUSION AND RECOMMENDATIONS

It was concluded that breed had great influence on LL and could be considered when selecting dairy cows for breeding. Adequate feeding by way of providing feed supplementation is necessary to increase LL, and therefore milk production. Maintaining a good body condition score will improve LL.

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