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Udder Morphometric Traits and Affected Dairy Milk Yield and Composition in Farms Animals

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ABSTRACT

Udder and teat typology: The trough (bowl) was the most common, followed by round, goaty, and pendulous udder types. In a similar vein, cylindrical teats were the most common, followed by funnel, bottles, and pears. The majority of cows with (bowl-shaped) udders wear 1 to 4 parity. (Pendulous-shaped) udders show a rising trend, with parity advancement being lowest in 1 parity cows and highest in 5 and above parity cows. The skin covering the teat is smooth when the udder is distended with milk, but it wrinkles after the milk is removed. Buffaloes have thicker teat walls, larger teat cisterns, longer teat canals, and different gland cisterns than other animals. Morphological measurements in cows increased as lactation progressed and lactation parity increased. According to several studies, the characteristics of the udder and milk yield are positively correlate. The relationship between udder characteristics and milk yield can be a useful tool in dairy production system animal selection. However, teat size and shape have no bearing on udder size, shape, or milk production. Understanding the anatomy of the mammary glands and how milk accumulates and is store can help dairy ruminants produce more milk, improve milking ability, adapt to longer milking intervals, and milk more quickly using streamlined procedures. Lactation stage, parity, breed, species, and time between milkings all had an effect on how the milk was distribute in the udder. Milk is stored in the alveolar and cisternal chambers of the udder. We recommend using the udder cistern area as a guiding parameter for the possibility of storing udder milk when determining the ideal milking frequencies for each ruminant based on the production system.

Introduction

Farmers' problem differ depending on the breed, breeding, producing region, feeding technique, and environmental factors. According to research milk production is actually in surplus in Europe but in deficit in Africa and the Americas (FAOSTAT, 2016). Milk production has increased due to dairy animal breeding efforts. The udder's size, connective tissue mass, and secretory tissue all contribute to an increase in milk production, udder secretory tissue hypertrophy is accompanied by significant milk production, which can only be seen phenotypically when the size of the udder cistern is critical for facilitating milk storage (Knight *et al.,* 1994; Marnet, 2013).

Cloning and embryo transfer are two scientific advances that may aid in the homogenization of cattle. As a result of this new orientation, it is important to consider the internal volume of the udder, the capacity of cell distension, and the kinetics of udder filling in addition to the outward volume of the udder in order to ensure better udder adaptation with the number of milkings (mechanical milking and robotic). Furthermore, (extensive and intensive) milk production methods maximize farmers' earnings. Because of the pressure placed on the udder when milk accumulates, cows with high milk production must be milked at least 3 times per day. Because of the increased frequency of milking, cow milk production has increased by 15-20%. (Eslamizad *et al.,* 2010). The udder morphology of the indigenous ewes was suitable for machine milking. Milk yield was positively correlate with udder morphology measurements and milk fractions, which can be used in breeding programs (Alhayani *et al.,* 2022)

There is a lot of information on Sudan cattle breeds' color, shape, body size, and horns, but not much is known about their udder features. For many breeds in Sudan, there are no systematic data on the type and confirmation of the teat and udder. It is essential to understand how the udder grows and how it relates to milk production.

Most animals lack production records, especially those raised in communities. Therefore, it becomes crucial to have some understanding of the udder's production potential while deciding between an economical and an uneconomical cow. Therefore, the current a study was conducted to examine the relationship between milk output and the morphometry of the udder and teat in Sudan cows at various stages of lactation.

Udder typology in cows

Udder morphometric Trieste

Studying the mammary glands anatomy and the way milk accumulates and is stored can help dairy ruminants produce more milk, milking ability, and adapt to longer milking intervals. (Salama *et al.,* 2004; Basavaraj *et al.,* 2019). Animals that keep a greater percentage of their milk in the alveolar compartment are more able to withstand prolonged milking intervals. (Knight and Dewhurst, 1994; Davis *et al.,* 1998; Salama *et al.,* 2004). Performance, teat and mammary gland health, and animal welfare all are impacted by the interaction of teat anatomical features, the milking apparatus, and the milking technique. (Mein, 2012). Teat length and other milking variables like milk production, average milk flow rate, stripping yield, and peak milk flow rate have all been linked to teat dimensions. (Weiss *et al.,* 2004). A multitude of milking techniques, in addition to teat shape, have been linked to milking efficiency, udder health, and milk quality.

One of the most crucial factors utilized to forecast production success is the cow's udder. For milking animals, a big udder with a high proportion of glandular tissue and an asymmetrical form is advantageous. Four mammary glands, or quarters, make up the udder. Each quarter is a distinct milk-secreting unit with its own teat for draining milk from the udder (Cowie, 1959). There are three components to the teat. The teat base are connected the udder, teat canal, the teat apex. Teat canal is made up of the greatest portion that lies between the teat base and apex. Farmers judge dairy cattle initially by looking at the udder to determine how well the animals can milking ability. Therefore, understanding the morphology of udder and teat forms and their relationship to milk output is increasingly crucial. When choosing dairy animals, the size and shape of the udder should be taken into consideration as they are highly significant conformation qualities that could play a significant effect in the adequacy of milk production (Bhuiyan *et al.,* 2004). High milk production requires a spacious udder. (Ahmed and Barbary, 2000). The size and morphology of the udder vary greatly from animals' individual to animal and between different lactation stages (Bharti *et al.,* 2015). The udder and teats' shape and size determine how much milk they produce and how well-suited they are for milking (Bardakcioglu *et al.,* 2011).

The typology of the udder is identified Through the use of the adopted visual appraisal approach by (Basavaraj *et al.,* 2019), thus that it can be divided into 4 types: bowl, goaty, pendulous, and round (Figure.1A). As per the used visual appraisal approach, the typology of the teats will be seen broadly and divided into 4 types: bottle, cylindrical, funnel, and pear-shaped teats (Figure.1B) (Basavaraj *et al.,* 2019; Ovesen *et al.,* 1972).

The trough (bowl) had the highest frequency, followed by the round, goaty and pendulous udder types. In a similar vein, the frequency of cylindrical teats was highest, followed by funnel, bottle, and pears. The majority of cows with (bowl-shaped) udders were 1 to 4 parity animals. With the advancement in parity being lowest in first parity cows and highest in fifth and above parity cows, (pendulous-shaped) udders show a rising trend. (Patel and Trivedi, 2018).

Udder measurement and teat

Teat length has been objectively measured for research purposes using a number of straightforward, quantitative techniques, such as measuring tapes, rulers, and calipers. When measuring, the tool is put close to the teat, and the scale is used to read the teat length. Additionally, use rulers and calipers to measure teat diameters. (McKusick *et al.,* 1999; Tilki *et al.,* 2005). The teat is placed between the caliper's jaws or the ruler is placed up against the teat at a specific position to measure its diameter. Many of the described udder and teat measuring methods are widely used (calipers, scoring, centimeters, tapes, rulers, transparent tubes, and open-ended). add to (ultrasonography) The preceding methods all have benefits and drawbacks, but up until now, there hasn't been an objective, accurate, exact, and quick way to measure teat diameters on a bigger scale with less work for the operator. In this regard, imaging systems have numerous advantages over other approaches. (Zwertvaegher *et al.,* 2011)

El-Ghousien *et al.,* (2004) Reported that the Morphological measurements increased as the number of lactations progressed. Friesian udders displayed a bigger distance between the two fore and the two rear teats. With greater width, depth, and length than buffaloes. Compared to Friesians, buffaloes had longer rear teats. The distance between the two front and back teats, as well as the average length and diameter of the fore teats, were comparable between the two species. As the lactation parity progressed in both species, the measures grew. In comparison to cattle, buffaloes have thicker teat walls, larger teat cisterns, longer teat canals, and unique gland cisterns .Patel *et al.,* (2016) all the measurements were found to increase with lactation parity order. The average length, width, and depth of the udder were non-significant, and the average length of fore teats was found to be non-significantly longer than rear teats.

several studies, the udders characteristics and milk yeild are positively correlated in Tunisia (Moufida, 2014) and India (Upadhyay *et al.,* 2014; Patel *et al.,* 2016). However, Ángeles (2014) reported that in local cows, there is a positive correlation between udder height and milk production as well as udder depth. Also Mention, Khan and Khan (2016) discovered genotype and phenotypic relationships between milk production and udder biometrics in Pakistan Sahiwal cows.

However, the correlation between udder characteristics and milk yield can be an important tool during selecting animals in dairy production systems(Ayadi *et al.,* 2014). Some characteristics of udder and teat measures as well as milk yield in various dairy cow breeds are described in tables (1, 2).

Anatomy and morphology of the cows udder

The mammary gland is a skin gland and is therefore external to the body cavity. An average Holstein cow's udder might easily weigh 50 kg (>100 lbs) when she enters the milking parlor to be milked. (Pandey *et al.,* 2018), As a result, the improvement of dairy cows farms goes through the selection of dairy cows with good body conformation and perfect udder morphology.

External anatomy

Jacobson, (1996); Banerjee, (1998) reported that the individual glands are arranged in two rows on either side of the median line of the body in the inguinal region. On each side are two normally functioning glands known as (quarters). The front and rear quarters do not have a distinct septum like the one found between the right and left parts udders. There is a longitudinal inter mammary groove, also known as the medial suspensory ligament, that divides the udder is right and left parts.(Hurley, 2010) The tensile strength of the median suspensory ligament is very high. For a balanced suspension, it situated in the udder's center of gravity. The front and rear quarters are separated by a thin membrane and are not recognizable to the eye. There is no internal crossover of the milk duct system of the quarters (glands).

The skin covering the udder is usually fine in texture and covered hairy. Except for the teats, the upper part of the cow's udder may be covered with wool, and usually stained by secretion see (Figure 2). Yellowish and greasy discharge from glands within the inguinal skin bags. These cutaneous invaginations, known as inguinal sinuses (sinus groin), and their sebaceous secretion have two fundamental properties: the presence of pheromones that allow mother-calf recognition and the decrease in friction characteristic of udder movement during lactation. (Ruberte *et al.,* 1994b). The teat is cylindrical or bottle in shape, type in elastic, and is associated with each gland and serves as the milk exit (Hurley, 2010), Teat size and shape are unrelated to udder size, shape, or milk production. When the udder is distended with milk, the skin covering the teat is smooth, but it wrinkles after the milk is removed.

Internal anatomy

Mammary suspensory system (Stroma)

The udder contains a small amount of connective tissue and a large amount of secretory tissue, which varies between animals. Connective tissue is a fibrous tissue composed of collagen and adipose cells. These tissues help to support the mammary gland so that it can perform optimally (milk production). Skin, superficial fascia, sub pelvic tendon, suspensory apparatus, and other tissues provide support for the udder. According to Akers and Nikerson, (2011) by the elastic tissue that surrounds the gland parenchyma and holds the udder forms the hanging device. It is divided into lateral plates (*L. laminae side*), which are responsible for attaching the udder to the trunk and perineum, and medial sheets (*L. medial laminae*), which are separated by a septum. These two complexes result in an externally inter mammary groove or udder suspensory ligament (*L. sulcus inter mammary*).

Alveolar system (parenchyma)

The parenchyma is the gland's secretory portion, which is made up of a network of ducts (Figure 3). It extends from the gland's internal secretory units (alveoli) to the most external, which is responsible for milk collection and transport, such as glandular portions (tanker) and papillary (nipple) lactiferous sinus. (Schmidt and Van Vleck, 1974). The mammary gland has a ductus system that extends from the alveoli to the streak canal, tubules in ducts act on milk drains from the alveoli to the gland cistern. The first step is to collect milk in the lumen of the alveoli and secretory (terminal) ductless Figure (3). The lobes empty into ducts, which drain into larger ducts until they reach the primary (mammary) ducts, which connected to the gland cistern (Aggarwal, 2007). In addition to participating in oxytocin-induced milk ejection, the system of ducts branching is not uniform (Cowie, 1984). The lactiferous sinus (Sinus lactiferous, Receptacle lactis) is divided into two parts: a glandular part or udder cistern (Part glandular), which is located inside the glandular parenchyma, and a papillary part or teats cistern (Part teats), which is located inside the nipple and communicates with the outside via a single papillary orifice (Figure 4). In cattle and sheep, these two cisterns are separated by a well-defined circular constriction (sphincter or ring) known as the cricoid.

It should be noted that the mammary alveoli are surrounded by an arteriovenous capillary system and myoepithelial cells, which, when activated by the vasoconstrictor hormone oxytocin (OT), expel the milk accumulated in the alveoli into the mammary cistern (milk ejection) (Alhayani *et al.,* 2022). The mammary cistern allows milk secreted between milkings to be stored sequentially in two compartments:

Alveolar compartment: formed by the glandular tissue Contains alveolar milk. Cisternal compartment: formed by the gland's ducts and cisterns as well as the teats. Cisternal milk is stored here. Depending on the breed, the percentage of milk that can be stored in the compartment cisternal ranges between 30% and 40% in cows. (Caja *et al.*, 2004; Ayadi *et al.,* 2003; Knight *et al.,* 1994). The breeds that show the best aptitude for mechanical milking are those that have a higher percentage of cisternal milk (Caja *et al.,* 2004).

Milk yield and composition in cows

Cows are typically milked in the early morning and late afternoon at intervals ranging from 12:12 to 10:14. (Armstrong, 1997; Brocard *et al.,* 2015).

Lactation persistency in cows

Lactation curve, a curvilinear pattern of milk production trait over the course of lactation. A lactation curve for dairy cattle begins with initial milk yield, increases to the peak of lactation, and then decreases until the cow is dried off. Lactation curve equations are useful tools that depict the lactation curve and can be used to predict parameters such as peak time, peak yield, and persistency. (Appuhamy, 2006). Persistency in milk yield production is one of the most economically important characteristics of the lactation curve. The lactation cycle is divided into four phases: early, mid, and late lactation (each lasting about 120 days) and the dry period (which can last up to 65 days). (Mukherjee *et al.,* 2017). Animals that produce milk with a high level of persistence, are considered economical in any dairy industry because they reduce and stabilize production costs, resulting in a higher profit (Mandal, 2018).

Lactation persistency is defined as a cow's ability to continue producing milk at a high level after the peak yield, which is an economically important trait of the dairy cattle production system (Torshizi *et al.*, 2019). According to various studies, several factors influence persistency, management, lactation number, level of milk yield, milking frequency feeding, gestation, the season of calving and production characteristics, environmental factors, reproduction traits, and the health of the dairy cow. This trait's heritability was low to medium, and a negative or positive genetic correlation between persistency and total milk yield in dairy cattle is attributed to persistency measures and data analysis methods (Portillo and Pollott, 2011; Boujenane and Hilal, 2012; Yilmaz and Koc, 2013; Bouallegue *et al.,* 2013; Mandal, 2018).

Persistence is associated with lower and later peak yield, and selecting cows for peak yield will improve persistency and lactation curve traits. An examination of the relationships between persistency and other functional traits reveals evidence that genetic improvement for persistency is feasible and advantageous. (Jamrozik *et al.*, 1998; Torshizi *et al.*, 2019). Dairy cattle selection has primarily focused on milk production, udder typology traits, and other functional traits because milk production has a significant economic impact on the dairy cattle enterprise in terms of dairy farm income (Tekerli *et al.,* 2000; Harder *et al.,* 2006).

Fraction of milk in the udder

The secreted milk in dairy ruminants is stored extracellularly within the anatomical udder compartments: The alveolar compartment stores secreted milk within the alveolar tissue lumen and empties its contents only if milk letdown occurs. (Ayadi *et al.,* 2004). The cisternal compartment, which receives milk from the alveolar compartment and stores it in large ducts as well as gland and teat cisterns, is immediately available for removal. (Ayadi *et al.,* 2014; Alhayani *et al.,* 2022).

Extracellular milk storage is divided into two anatomical compartments: alveolar milk (secreted milk stored in the lumen of alveolar tissue) and cisternal milk (milk drained from the alveoli and stored within the large ducts and the gland and teat cistern) (Wilde *et al.,* 1996). Milk secretion rate and milk emission kinetics are affected by the size of the mammary cisterns(Stelwagen, 2001).

Milk partitioning between compartments varies by species, breed, age, lactation stage, and milking interval, and helps to explain the change in milk yield and milk composition that occurs when a milking interval is extended to 24 hours. (McKusick *et al.,* 2002). The volume and percentage of cisternal milk decrease as lactation progresses in dairy cattle. Cisternal milk volume decreases as lactation progresses, but the percentage increases. (Caja *et al.,* 2004). Animals that store a large amount of milk in the gland cistern produce more milk, they milked faster and can tolerate longer milking intervals. (Ayadi *et al.,* 2003; Salama *et al.,* 2004; Castillo *et al.,* 2008). Long milking intervals may have a negative effect on milk yield in dairy sheep due to mammary cistern size and milk storage characteristics. (Castillo *et al.,* 2008), dairy goats (Salama *et al.,* 2004), and dairy cows (Knight and Dewhurst, 1994), The proportion of total milk that can be stored within the cistern varies greatly between species. Dairy cows store 30% of their total milk yield in the cistern after a normal milking interval (8-16 h) (Table 4).

Reported (Ayadi *et al.,* 2004) that cisternal and alveolar milk increased with milking interval and represented on average 30 and 70% of the milk stored in the udder cows, respectively. Total fat yield tended to increase for alveolar milk with longer milking intervals, but it increased markedly for cisternal milk, showing that fat globules did not pass freely from alveoli to cistern between milkings. (Stelwagen *et al.,* 1996; Ayadi *et al.,* 2003).The protein content was higher in the rear quarters than in the front quarters. With longer milking intervals, milk protein content increased in the cisternal milk fraction and tended to increase in the alveolar milk fraction, but values did not differ significantly between the cisternal and alveolar fractions or between the front and rear quarters. Total protein yield increased with milking interval in both fractions, indicating that casein micelles moved more freely than fat globules from the alveolar to the cisternal compartment, and the concentration of milk components is significant affected by the location of milk storage in the gland. The distribution and accumulation of cisternal and alveolar milk fractions in dairy cows vary with milking interval (Stelwagen *et al.,* 1996; Ayadi *et al.,* 2003). The fat and protein contents of the dairy cow udder are higher in the front than in the rear (Labussie`re, 1985) Knowledge of the interaction between milk component secretion and milk storage in the udder at various milking intervals can be useful in developing appropriate management systems and milking routines, particularly when using automatic milking (Weiss *et al.,* 2002). (Bruckmaier *et al.,* 1994; Pfeilsticker *et al.,* 1996; Ayadi *et al.,* 2003).

Lactation hormone

Prolactin (PRL)

Prolactin is a protein hormone secreted by the pituitary gland's anterior lobe. It plays a crucially important in the production of milk. It rises after birth in response to lactation and keeps milk secretion and production going. (Dybus *et al.,* 2005).It is in charge of a wide range of physiological actions in vertebrates such as fish, amphibians, reptiles, and mammals (Forsyth and Wallis, 2002; Wallis, *et al.,* 2005). Furthermore, it was named (prolactin) for its stimulatory effects on mammary gland development and lactation. PRL's amino acid sequence and tertiary structure are similar to that of growth hormone (GH), which is also secreted from the anterior pituitary gland (Cooke and Liebhaber, 1995).

The levels of the reproductive hormones estrogen, progesterone, placental lactogen, prolactin, and oxytocin fluctuate during reproductive development or function and act directly on the mammary gland to cause developmental changes or to coordinate milk delivery to the offspring. (Neville *et al.,* 2002).

Change some reproductive hormones, such as estrogen (E), progesterone (P), placental lactogen (PL), prolactin (PRL), and oxytocin (OX), with the reproductive state and All, have a direct effect on the mammary gland (Hovey *et al.,* 2002).

PRL is required for milk production. PRL is well known for its lactogenic action in ruminants as well as its critical role in the peripartum interval for the start of lactation (Tucker, 2000). However, there is an intriguing contradiction in PRL's possible role during lactation. The milking parity order influences milk hormone (PRL), and there is a link between milk hormone (PRL) and milk components (Rubaei *et al.,* 2019), The outcomes demonstrated by Vupru *et al.,* (2016). PRL levels were significantly higher around calving and fell sharply thereafter. The hormone remained almost constant during mid-lactation and declined during late-lactation. PRL was positively correlated with lactation yield.

Growth hormone (GH)

GH is required and important for milk production In ruminants. GH is the main galactopoietic in animals. Its exogenous contribution in the form of bovine somatotropin (BST) increases milk production and favors cow lactation persistence. (Bauman *et al.,* 1999), sheep (Fernández *et al.,* 2001), and in goats (Baldi *et al.,* 2002). GH regulates the flow of nutrients to the mammary gland, favoring its affluence and facilitating the secretion of dairy components by mammary epithelial cells (Neville *et al.,* 2002).

Furthermore, their actions are anti-apoptotic (Baldi *et al.,* 2002) and stimulant of cellular renewal in the udders during lactation (Capuco *et al.,* 2001), assisting in the maintenance of the mammary cell population throughout lactation and thus contributing to its persistence in ruminants.

In farm animals, growth hormone (GH) plays a role import in ductal development, glucocorticoids and thyroid hormone is required for milk secretion, and insulin is required for the growth of the mammary gland and development. (Hovey *et al.,* 2002; Neville *et al.,* 2002). As a study showed by (Vupru *et al.,* 2016)The levels of all hormones varied significantly across the lactation cycle, but there was no significant difference between strains. GH levels were significantly higher around calving and then dropped sharply. During mid-lactation, the hormones remained almost constant, and decreased during late lactation. Lactation yield is positive correlated with GH.

Factors affecting udder morphometric traits and milk yield in dairy cows

The udder is regard as one of the most important traits in dairy animals, Because of its physiological and functional characteristics (Labussiere, 1988). As a result, it has been report in the literature that various factors such as phenotype, genotype, milking interval, breeds, nutrition, age, parity, stage or length of lactation, and milking frequency influence udder traits and milk production. (Dahl *et al.,* 2000; Perea *et al.,* 2000; Ciappesoni *et al.,* 2011; Martínez *et al.,* 2011; Bogucki, 2018). Also taken Consider the cows' individual characteristics, anatomy, and udder physiological efficiency (Bogucki, 2018).

Table.1 Teat measurements traits and milk yield in different breed of dairy cows.

	Teat measures (cm)													
Breed	**DMY**	**TL**				**TW**				**DT**				**Reference**
		Front left	Frontwright	Rear left	Rear wright	Front left	Front wright	Rear left	Rearwright	Front	Rear	Left	Wright	
Local Cattel		6.56	6.23	7.90	7.38	3.06	2.90	3.37	3.11	14.16	9.77	9.54	9.22	(Radi and Mohmmed., 2012)
Buffaloes Iraqi		6.25	6.25	7.45	7.45	3.32	3.32	3.61	3.61	16.89	10.92	10.49	10.49	(Baghdasar et al., 2011)
Crossbred	-	6.5	6.5	5.3	5.3	2	2	2	2	11.5	5.3	4.7	4.7	(Patel et al., 2016)
Zebu cows	-	4.13	4.00	3.83	2.85	2.04	2.08	1.90	1.91	-	-	-	-	(Mingoas et al., 2017)
Murrah Buffaloes	6.65	7.37	7.53	8.23	8.12	2.65	2.71	2.80	2.89	-	-	-	-	(Prasad et al., 2010)
Dairy Cows	-	5.88	5.88	5.88	5.88	2.23	2.23	2.23	2.23	14.06	8.16	9.56	9.56	(Coban et al., 2009)
Holstein cows	14.09	5.87	5.85	4.92	4.92	2.50	2.50	2.58	2.58	18.6	8.69	-	-	(Rogers & Spencer, 1991)
Sahiwal cattle	-	5.30	5.30	4.66	4.66	-	-	2.22	2.22	-	8.99	6.75	6.75	(Sinha et al., 2021)
Dairy Cows	13.11	6.6	6.7	5.7	5.6	2.7	2.7	2.8	2.8	_	_	_	_	(Weiss et al., 2004)
Crossbred		5.73	5.7	5.7	5.7	2.68	2.6	2.6	2.6					(Patel & Trivedi, 2018)
Gir Cows		9.26	9.26	8.64	8.64	3.7	3.7	3.65	3.65					(Modh et al., 2017)

[1]DMY: Daily Milk yield;[2]TL: teat length; TW: teat width;DT: distance between teats.

Table.2 Udder measurements traits and milk yield in different breed of dairy cows

		Udder measures (cm)						
Breed	**DMY**	**UC**	**UL**	**UD**		**UW**		**Reference**
				Front	Rear	Front	Rear	
Crossbred	_	59	_	14	25	21	17	(Y. G. Patel et al., 2016)
zebu cows	_	_	39.51	24.02		19.8		(Mingoas et al., 2017)
Murrah Buffaloes	6.6		54.2	50.6		15.6		(Prasad et al., 2010)
Dairy Cows	_	_	_	54.92	54.30	_		(Coban et al., 2009)
Sahiwal cattle	_	136.35	60.47	53.65		71.42		(Sinha et al., 2021)
Holstein cows in Egypt	P= 11.28	46.55	40.46	21.29	26.26			(Rohayem et al., 2019)
	M= 14.74	53.41	44.57	27.97	28.20			(Rohayem et al., 2019)
Crossbred			58.24	23.06		65.45		(Patel & Trivedi, 2018)
Gir cows			61.95	25.62		62.99		(Modh et al., 2017)

[1]DMY: Daily Milk yield; [2]UC: udder circumference; UL: udder length; UD: udder depth, UW: udder width.

Table.3 Milk production and composition in various dairy cow breeds

Breed	Parity order	MY (L)	Fat %	Protein %	Lactose %	Total solid %	Reference
Holstein Cows		27.7	4.07	3.13			(Ayadi et al., 2004)
Local cows			3.35	2.75	3.45	8.19	(Rubaei et al., 2019)
Holstein-Friesian	Primiparous	28.75	3.71	3.31			(Bogucki, 2018)
	Multiparous	34.52					(Bogucki, 2018)
Jersey	Primiparous	13.03	5.62	3.87			(Tierz., 2005)
	Multiparous	15.93	5.71	4.00			(Tierz., 2005)
Holstein		48.82	3.23	2.54			(Tacoma et al., 2015)
Jersey		33.90	4.28	3.24			(Tacoma et al., 2015)
Holstein cows	Multiparous	41.48	3.7	3.2			(McWilliams et al., 2021)

Table.4 Cisternal milk (L) according to the stage of lactation, parity, and intervals between milking in different breeds of cows.

Breeds	Stage of lactation	Parity order	Interval milking	Cisternal milk (L)	Alveolar Milk (L)	Reference
Friesian-Holstein	Mid	Multiparous	8h	1.88	6.62	(Knight et al., 1994).
Holstein cows		3Multiparous 1Primiparous	8h	3.3	5.26	(Ayadi et al., 2003)
Friesian cows	Early	14Multiparous 4Primiparous	12 h	1.22	2.45	(Caja et al., 2004)
	Mid		12 h	0.62	2.06	
	Late		12 h	0.49	0.66	
Friesian cows	Early	6Multiparous	1 h	0.14	4.09	(Knight et al., 1994)
			12 h	4.97	9.98	
	Late	8Multiparous	1 h	0.45	1.11	
			12 h	2.54	4.20	

Fig.1A Teats shapes (Basavaraj *et al.*, 2019).

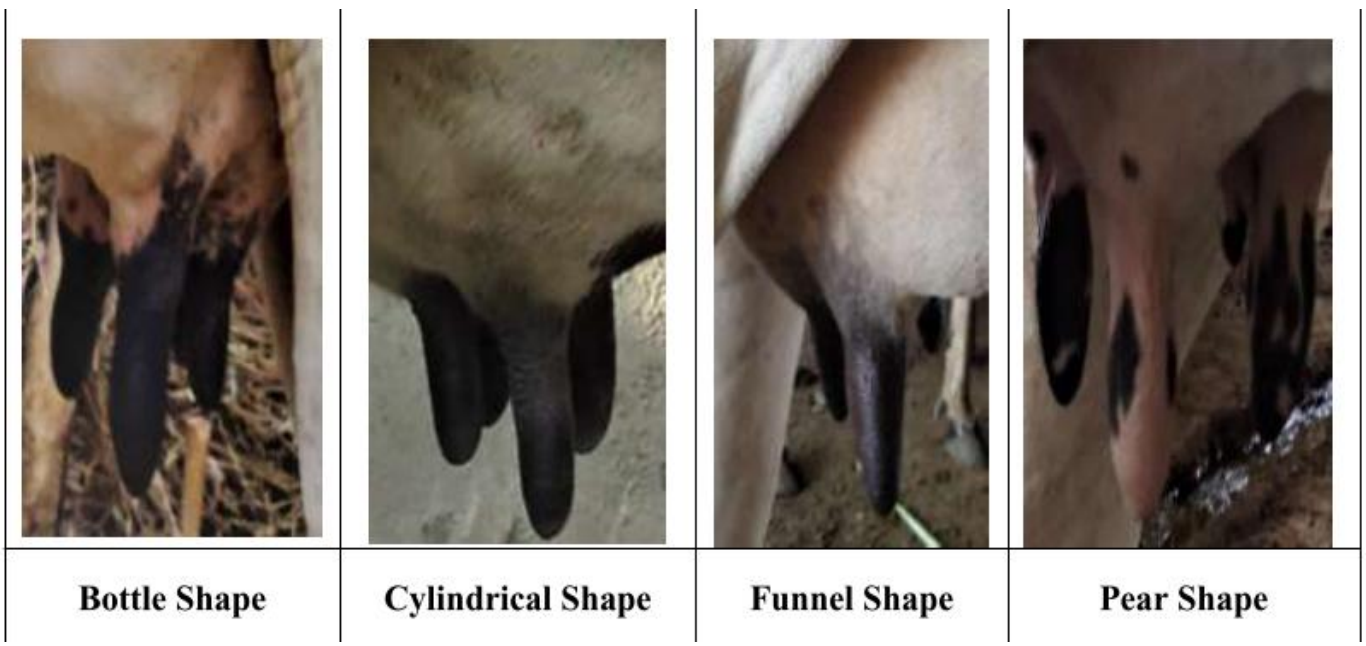
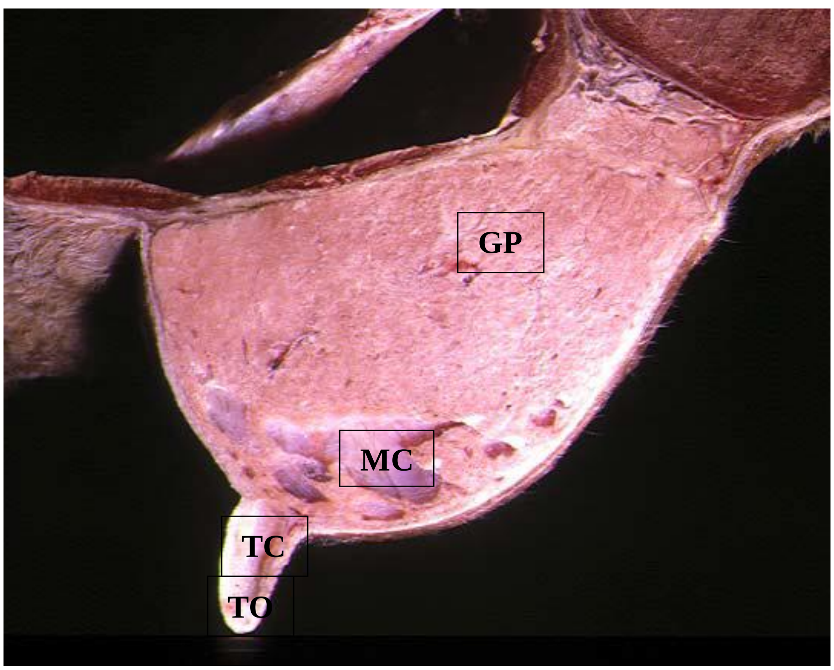


Fig.1B Udder shapes (Basavaraj *et al.*, 2019).

Fig.2 External morphology of the udder of Friesian cows.

Fig.3 The anatomical shape of a dairy sheep udder obtained through epoxy injection and plastic corrosion (left) and a detail of the ductal system, including ducts and alveoli (right) (Caja et al., 2000).

Fig.4 The internal structure of the ovine udder: glandular parenchyma (GP), mammary cistern (MC), teat cistern (TC), and teat opening (TO). (Ruberte *et al.*, 1994b and Caja *et al.*, 2000)



Stage of lactation

The review of the literature on the change in milk constituents during different stages of the lactation cycle revealed that milk fat, protein, and lactose varied significantly with the stage of lactation in cows, are high in early lactation, increase in mid-lactation (peak milk yield), and decrease during mid-to late-lactation. (Holdaway *et al.,* 1996; Chaudhary *et al.*, 1998; Taralik, 1998; Sarkar *et al.*, 2006; Vupru *et al.,* 2016). Furthermore, Morgan (1991) reported the lowest milk fat percentage values for Hereford cows during peak milk yield (middle of lactation).The cycle of lactation is divided into four stages: early, mid, and late lactation (each lasting about 120 days), as well as dry periods (which should last as long as 65 days). In an ideal environment, cows should calve every 12 months (Mukherjee *et al.,* 2017).

Parity order

Total lactation milk yield and 305-day milk yield were affected by the year into parity order interaction, but actual milk yield was not. Parity order also had an effect on total lactation milk yield, 305d milk yield, and fat percentage (Pawar, 2012).

As the number of parity increased, all data showed a gradual increase in the depth, length, width, and volume of the udder. The differences in udder morphometry observed in different parity orders were significant (Găvan and Riza, 2021). The correlations between milk yield and udder width and was found positive and significant while correlations between milk yield and udder length and udder depth were non-significant (Modh *et al.,* 2017).

Breed

Cow breeds are divided into three groups based on their level of milk production: cows with a high milk yield, ranging from 16.66 to 23.33 kg per day (Holstein, Holstein-Friesian) (Ayadi *et al.,* 2004; Bogucki, 2018). Cows have been chosen for medium production (including Egyptian crossbred Holstein cows, Jersey, and local Cattel) with daily milk yields ranging from 10 to 22 kg (Rohayem *et al.,* 2019; Tierz., 2005; Radi and Mohmmed., 2012). Furthermore, cows with low milk production or non-dairy cows weighed production rang less than 10 kg (including Zebu cows, and Sahiwal cattle) (Mingoas *et al.,* 2017; Sinha *et al.,* 2021).

Milk composition changes with breed have previously been reported in various types of literature As a result, the milk fat content of Jersey cows is 5.71%. (Tierz., 2005) and 4.07% in Holstein Cows (Ayadi *et al.,* 2004).

Local cows had a low milk fat content (3.3%). Holstein-Friesian cows (3.7%) (Rubaei *et al.,* 2019; Bogucki, 2018). There was little variation in milk protein content with the breed, with values ranging from 2.75 to 3.78% (Rubaei *et al.,* 2019; Tierz, 2005).

Udder morphology traits are different by different types from cow breeds. However, teat length, width, and distance teats in Local Cattle, Buffaloes Iraqi, and Holstein cows dairy cows (Radi and Mohmmed, 2012; Baghdasar *et al.,* 2011; Rogers and Spencer, 1991) compared to zebu cows, Sahiwal cattle, and Crossbred dairy cows (Mingoas *et al.,* 2017; Sinha *et al.,* 2021; Patel *et al.,* 2016). The correlations between milk yield and various udder measurements viz udder length, udder width, and udder depth were found positive and significant (Patel *et al.,* 2016).

Milking interval

Cows with the earliest increases in plasma lactose concentrations during milk accumulation lost more milk when milking intervals were extend. Albaaj *et al.,* (2018)

Increasing milking intervals in dairy cows causes a curvilinear decrease in milk secretion rate. The rate of secretion remains relatively constant until 12 h, then decreases slightly from 12 to 16-18 h before rapidly decreasing (Elliott *et al.,* 1960; Wheelock *et al.,* 1966; Stelwagen *et al.,* 2008). Longer milking intervals necessitate more subsequent milkings to restore the previous milk yield.

Milking frequency

Several studies have shown that frequent milking during early lactation increases milk production not only during the frequent milking period but also throughout the lactation (Hale *et al.,* 2003; Wall and McFadden, 2007; Eslamizad *et al.,* 2010). Milk production is increase by frequent milking of dairy cows during early lactation via mechanisms within the mammary gland. Furthermore, Frequent Milking is a valid and efficient model for studying the effects of frequent milking in dairy cows during early lactation (Wall and McFadden, 2007).

Primiparous cows respond better than multiparous cows to high milking frequency (HMF), that is, four times a day. Nonetheless, the number of cows in most studies examining six-times-a-day milking was relatively small (Eslamizad *et al.,* 2010; Soberon *et al.,* 2010). Increasing milking frequency to six times per day for the first 21 days leads to increased milk production throughout the lactation and into the following lactation. Throughout the lactation, milk fat and protein yields were higher for the six-milked first and second-lactation cows.(Shoshani *et al.,* 2017).

Cows are generally milked twice a day, with milking intervals ranging from 8 to 16 hours, though research has been conducted to determine animal milking management systems that combine maximization of quantitative and qualitative production with reduced work constraints. According to research, for a frequency of two milkings per day, a 12-12 interval would benefit high producing cows (3-5% gain over a 10-14 interval) (Marnet and McKusick, 2001), Several studies have been conducted to determine this limit, which ranges between 10 and 18 hours depending on the type of animal(Stelwagen *et al.,* 1996). These variations could be due to inter-individual differences or to anatomical features of the udder.

In fact, animals with large udder cisterns produce more milk and can go longer between milkings than animals with small udder cisterns, which cannot transfer their alveolar milk and must put a brake on secretion sooner. This observation has been confirm in cows. (Knight *et al.,* 1994; Ayadi *et al.,* 2003). As a result, it has been demonstrate that milk production increases when milk can flow continuously from the udder (Stelwagen *et al.,* 1996).

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