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The Importance of Buffalo Milk in the Curd Manufacture of Sri Lanka

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Abstract

Sri Lanka is a developing country located south of India, in the Indian ocean. It is a country with multiple cultures, ethnicities and languages, and it is rated as "high" on the Human Development Index (HDI). The total population is 20.9 million, of which 28% are employed in the agricultural primary production. Nevertheless, the agricultural sector of Sri Lanka is limited in terms of mechanization, market-oriented production and agriculture-based industries. The total number of farmers in Sri Lanka is estimated to be around 11 million, of which 3.5 million keeping livestock. In year 2017 there were 444,912 domesticated buffaloes in Sri Lanka and the buffalo milk-production increased by the double from 2009 to 2017. Buffaloes are unique in their way of surviving during very hard nutritional conditions as well as under less beneficial management. This makes them favourable as milk producers at certain places with hard conditions.

The small-scale dairy processing is found to play an important role in the marketing of Sri Lankan dairy products. Products with high production value, such as curd, is manufactured by farmers themselves for both private use and for resale. Curd is one of the oldest fermented milk products in Sri Lanka, and can be made from both buffalo milk and cow milk. The buffalo curd is named *Meekiri*, and curd made of cow milk is named *Deekiri*. In the process of making curd, the lactose in the milk is converted into lactic acid. Buffalo milk is preferably used in the curd production, rather than milk from cattle. Because of the higher content of fat and protein, buffalo milk gives a higher yield of curd, as well as a creamier texture.

In this project, milk from three buffaloes and from six European cattle, was collected and analysed in terms of fat-, protein-, lactose- and solids-not-fat content. The other part of this project was to produce buffalo curd (Meekiri) and cow curd (Deekiri). With help of a test panel, the products were evaluated and compared considering appearance, odour, colour, texture, flavour and syneresis.

The results regarding milk composition showed that buffalo milk had a generally higher content of fat, protein, lactose and solids-not-fat than the European cattle breeds, especially concerning the fat content. There was little variation in lactose between all milk samples. Furthermore, the visual appearance of the two curds was that Meekiri had a whiter colour, while Deekiri had a distinct yellow colour. Also, Meekiri was slightly firmer with a sourer taste than the milder tasting Deekiri. A panel of judges tasted the two curds and ranked Meekiri slightly higher in all perspectives. However, some people did prefer Deekiri with its mild taste and less firm texture. It was less syneresis in Meekiri, most probably because of its higher fat- and total solid content.

Curd is not yet very well known in the western world, for example in Scandinavia, due to the lack of buffaloes in this area. The priority of this study was to investigate and collect information about buffaloes as a dairy animal in Sri Lanka and its importance in the curd manufacture of the country.

Keywords: Sri Lanka, curd, Meekiri, Deekiri, buffalo milk, milk composition, milk fat, fermented milk products

Sammanfattning

Sri Lanka är ett utvecklingsland som ligger söder om Indien, i Indiska oceanen. I landet finns en stor variation av olika kulturer, etniciteter och språk, och det rankas som ”högt” på det mänskliga utvecklingsindexet (HDI). Den totala folkmängden är 20.9 miljoner, av vilka 28% är sysselsatta inom den agrara primärproduktionen. Den agrara sektorn i Sri Lanka är dock begränsad när det kommer till mekanisering, marknadsorienterad produktion samt inom de lantbruksbaserade industrierna. Det totala antalet lantbrukare i Sri Lanka uppskattas utgöra omkring 11 miljoner, av vilka 3.5 miljoner äger boskap. År 2017 fanns 444,912 domesticerade bufflar i Sri Lanka och buffel-mjölkproduktionen ökade med det dubbla mellan 2009 och 2017. Bufflar är unika i sitt sätt att överleva under mycket svåra näringsförhållanden, likaså under sämre skötselförhållanden. Detta gör dem gynnsamma som mjölkproducenter i krävande miljöer.

Den småskaliga mejeriproduktionen har visat sig spela en viktig roll i marknadsföringen av sri lankesiska mejerivaror. Produkter med högt mervärde, såsom curd, produceras i många fall direkt på gården, dels för hemmabruk och dels för försäljning. Curd är en av de äldsta fermenterade mjölkprodukterna i Sri Lanka, och kan göras av både buffelmjölk och komjölk. Curd gjord på buffelmjölk kallas *Meekiri*, och curd gjord på komjölk kallas *Deekiri*. I processen då curd bildas konverteras laktos i mjölken till mjölksyra. Buffelmjölk används med fördel framför komjölk i produktionen av curd. På grund av den högre andelen fett och protein, så ger buffelmjölk ett högre utbyte curd, likväl en krämigare konsistens.

I detta projekt insamlades mjölkprover från tre bufflar och från sex europeiska kor. Halterna av fett, protein, laktos, och ”solids-not-fat” analyserades i mjölkproverna. Den andra delen av projektet bestod av att producera två typer av curd, gjorda av buffelmjölk och komjölk. Dessa två jämfördes sedan med hänsyn till utseende, doft, färg, konsistens, smak och syneres, med hjälp av en testpanel.

Resultaten gällande mjölksammansättningen visade att buffelmjölken generellt hade en högre mängd fett, protein, laktos, samt torrsubstans jämfört med de europeiska ko raserna, särskilt gällande fetthalten. Laktoshalten varierade i mycket liten grad i alla mjölkprover. Vidare visade det sig att Meekiri hade en vitare färg än Deekiri, som hade en tydlig gul nyans. Meekiri hade även en fastare konsistens och något surare smak jämfört med Deekiri som var mildare i smaken. Testpanelen rankade Meekiri något högre gällande alla perspektiv. Dock, vissa människor föredrog Deekiri med dess mildare smak och mindre fasta konsistens. Syneres visade sig vara lägre i Meekiri, förmodligen på grund av dess högre fett halt och mängd ”solids-not-fat”.

Curd är fortfarande en ovanlig mejerivara i västvärlden, exempelvis i Skandinavien, på grund av bristen på bufflar i dessa områden. Fokus i denna studie var att undersöka och samla information om bufflar som mjölkproducenter i Sri Lanka, samt att visa på dess viktiga roll i produktionen av mejerivaran curd.

Nyckelord: Sri Lanka, curd, Meekiri, Deekiri, buffelmjölk, mjölksammansättning, mjölkfett, fermenterade mjölkprodukter

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1 Introduction

The Democratic Socialist Republic of Sri Lanka, more commonly known as Sri Lanka, is an island country located in the Indian ocean in the south of Asia. The country has multiple cultures, ethnicities and languages (Robert 2006), and is, together with the Maldives, one of the two countries in South Asia rated as "high" on the Human Development Index (HDI). Sri Lanka also has the highest income per capita amongst the South Asian Nations (UNDP 2018). The nation's total population is 20.9 million, of which 28.5% are occupied in the agricultural primary production. In fact, the agricultural sector contributes to 10% of the Gross domestic product (GDP). Nevertheless, the mechanization level of Sri Lankan agriculture is low and the market-oriented production is lacking. Also, the agriculture-based industries are limited (FAO 2018).

Smallholders dominate the agricultural sector of Sri Lanka, and about 70% of the total population are provided income from this sector. The total farm population is estimated around 11 million, of which 3.5 million keeping livestock (Ibrahim 2000). In 2017 the cattle population was 1,399,815, whilst it was 444,912 domesticated buffaloes. Both cow milk and buffalo milk production increased by the double in the last decade (Thomas 2004). A production of 404,600,001 and 78,088,639 litres, for cow and buffalo respectively, was obtained year 2017. At the same time, the import of milk and milk products was almost hundred times higher than the country´s exportation. 98,863,896 kg versus 1,048,411 kg (DAPH 2019).

In Sri Lanka, the milk industry includes processing of locally produced milk. Common is also combined processing of imported milk powder and local milk to produce yoghurt and ice-cream. The small-scale dairy processing is found to play a small but important role in the marketing of Sri Lankan dairy products. Products such as curd, which is often manufactured by farmers themselves, is of high importance due to the added values of the end product. The milk farmers retain about 15 % of their production for family consumption and the rest is delivered to the milk collection centres or sold locally. However, approximately 34% of the milk available on the market is not processed, and is instead marketed either as raw or indigenous products such as locally-produced curd (Ibrahim 2000).

Kurunegala, with its land area of 4772.83 km^2, is the district in Sri Lanka having the largest buffalo population as well as the highest buffalo population density. This reflects the important dual-purpose role of buffaloes, as both draught animals and milk producers, in this paddy-cultivating district (Perera 2001). The mid-country zone, including the Kandy district, has the highest proportion of dairy cattle, mainly of the European breeds Jersey, Ayrshire and Friesian. The herd sizes are variable with a mean of 3.0 lactating cows. This zone also has some buffaloes for draught and milk production (Ibrahim 2000). The majority of smallholders are crop-livestock farmers, growing vegetables and cultivating paddy. The milk from their cattle is often a secondary source of income (Borghese 2008).

Sri Lanka is located 7º00´ north of the equator and is therefore having a tropical climate. The opposite poles of the island are affected alternately by the two monsoon seasons, resulting in high rainfall in total. In the southern central region of Sri Lanka, in the mountains, the average rainfall measures around 5000mm annually. The mountains do have an impact on temperature as well, giving cooler weather with seasonal differentiation, and an average temperature of 16°C. In contrast, in the north temperatures can raise up to 40°C (Climate and Weather 2019).

1.1 Aim

Buffalo curd production is important both for the commercial production, as well as for small-scale farming in Sri Lanka. The aim of this study is to investigate the importance and benefits of using buffalo milk in the curd manufacturing process. The milk components (fat, protein, lactose, solids-not-fat and pH) of buffalo and European cattle will be compared and the final products characterised.

1.1.1 Hypotheses

1. The buffalo milk has a richer nutritional value than milk from European cattle, in terms of fat-, protein-, lactose- and solids-not-fat content.
2. Due to the higher content of nutrients in buffalo milk, especially regarding the fat content, the characteristics of Meekiri are to prefer in all perspectives.
3. The syneresis percentage is lower in Meekiri compared with Deekiri, due to its higher fat- and total solid content.

1.2 Buffalo breeding

In many countries, the buffaloes play an important role economically, both by being useful draught power and for production of meat and milk. Buffaloes are unique in their way of surviving during very hard nutritional condition as well as under less beneficial management. This makes them favourable as milk producers at certain places, for example in tropical climate (Danielsson & Niva 2007).

The buffalo does not mind consuming mature fibrous forages, that cattle usually refuse to eat. Furthermore, it has a more voluntary feed intake and greater rumen capacity than cattle. Also, the buffaloes total microbial count and cellulolytic bacteria as well as their bacterial growth in rumen is significantly higher. The factors above contribute to buffalo's better ability to utilize roughages of poor quality, compared to cattle. Buffaloes also have an advantageous position in terms of weight gain. Due to its superior body weight at birth, and their higher daily weight gain, the buffalo is more suitable for meat production compared to cattle (Perera 2001).

1.2.1 Breeds of the buffalo population

The two major genetic variants of the domestic water buffalo (*Bubalus bubalis*) are the Swamp buffalo with its swept-back horns, and the River buffalo which often has curled horns. There are eighteen breeds of the River buffalo in South Asia. The most commonly known improved breeds are Murrah, Nili-Ravi, Surthi, Jafarabadi, Nagpuri and Mehsana (National Research Council 1981). Approximately 67% of the total domestic buffaloes in the world, are of the river type. The breeds of river buffaloes are categorized into five groups, based on certain characteristics. The group named Murrah includes, among others, the breeds Murrah and Nili-Ravi, and is a group selected for milk production (Perera 2001).

The Murrah breed has been introduced in Sri Lanka, as well as many other countries, from the Indian state Haryana. Murrah buffalo has a massive and compact frame and can be very heavy. The male can weigh up to 800 kg while the female reaches around 350 to 700 kg. This breed is an important and good milk producer, with a milk yield around 1400 – 2000 kg, with 7% fat, in a 305 days' lactation. Their udders are well developed, with long teats placed widely and with salient milk veins (Perera 2001)

Nili-Ravi, originally from the state Punjab of Pakistan, was introduced to Sri Lanka in the 1990 century. Nili-Ravi is not much unlike the Murrah breed phenotypically. It is a medium - large sized buffalo with short, but big-boned legs. The male can weigh up to 700 kg and the female weighs at most 550 kg. The udder of Nili-Ravi is equal to the udder of the Murrah buffalo, and the milk yield, with 7% fat, is around 1500 – 2000 kg in a lactation of 305 days (Perera 2001).

1.2.2 Challenges in buffalo husbandry

Buffaloes do have limitations, which however are mostly caused by the environment rather than by the animal itself. For instance, milk yield and growth are both directly connected to management and nutrition (National Research Council 1981). Nevertheless, a few innate limitations of the buffalo are known. *Silent heat* is a big problem in buffalo milk production. Buffaloes suffers from direct sunlight but does not show it with any visual signs (Olsson 2007).

Compared to cows, the density of buffaloes' sweat glands is 10 times lower. Also, buffaloes have sparse hair with a low degree of protection against the sun. This is why these animals have difficulties to handle the heat during the days, and they are dependent on water and wallowing (De Rosa *et al.* 2009). Also, in truly cold climate, buffaloes are less able to adapt than cattle. Cold winds and sudden temperature drops may cause pneumonia and death in buffalo (National Research Council 1981). With better applied management and routines, the dairy production from buffalo could be improved and become more profitable.

The dairy water buffalo has, compared with cattle, late maturity and long calving intervals (Olsson 2007). The buffalo also have shorter lactation length, longer dry period and lower milk production (Table 1). This can be explained by the less developed breeding program compared to cattle (Thomas 2004).

Table 1. *Productivity facts of buffaloes and cattle, illustrated from Thomas 2004*

	Buffalo	Cattle
Age at first calving (months)	40-60	24-30
Calving interval (months)	15-18	12-13
Lactation length (days)	252-270	300
Dry period (days)	60-200	60-90
Milk yield (kg/lactation)	1700-2500	6000-7000
Productive life, of total lifetime	35%	52%

1.3 Buffalo milk

During the 1990s, there has been a noticeable increase of buffalo milk production throughout Asia. This indicates the buffalo´s importance and suitability as dairy animal in tropical climate (Perera 2001). Around 13% of the global yearly production of milk, measuring 82 billion litres, is buffalo milk. The milk production from cattle measures 551 billion litres per year, estimated as 84% of the total global milk production (Ménard 2010).

1.3.1 Milk yield and management

The composition of both buffalo and cow milk is affected by factors in the environment, e.g. feeding system, frequency and method of milking, stage of lactation and individual variation between the cows (Tripaldi 2008). The fat content in milk can be influenced by changing the nutrition of the feed. Higher fat content in the milk is a result of high fibre feed, giving an increased proportion of propionic acid, whilst acetate and the butyric acid levels are decreased (Danielsson & Niva 2007).

The environment, when it comes to heat, might affect the milk yield to some extent. However, not much is known about how the milk yield of buffaloes are affected by this factor. In cattle, reduced milk yield and fertilization rate have been linked to insufficient heat dissipation (De Rosa *et al.* 2009).

Dairy buffalo or cattle require a diet containing the necessary nutrients to sustain a healthy life, preventing loss of bodyweight. The animals need to be maintained with nutrition to ensure optimum production. Neither undernourished nor too fat animals are fully suitable for production. These conditions also make the animals more susceptible to diseases and low fertility (Ibrahim 2000). Several feeding systems, using locally produced animal feed, are followed by farmers in Sri Lanka, based on their own experiences (Pathak & Verma 1993). Feed sources in Sri Lanka are not severely limited in general, but they can be seasonally. Both buffaloes and cattle graze on paddy land, although feed in form of concentrate is used significantly and widespread. 55% of the buffalo- and/or cattle-keeping households are using concentrate feeds based on copra cake and rice bran (Ibrahim 2000).

1.3.2 Milk composition

The river buffaloes are most often kept as milk producers with its daily milk yield of around 7 – 10 litres. When comparing buffalo milk and milk from cattle, there are some clear differences, especially when it comes to fat content and the fatty acid composition. Buffalo milk contains about 17.5% total solids, including 7.5% fat, 4.3% protein and 4.8% lactose. The milk of European cattle only contains around 12.7% total solids, including 3.9% fat, 3.2% protein and 4.6% lactose (Olsson 2007). The buffalo milk has larger casein micelles than milk from cattle, moreover the milk contains higher content of calcium and phosphorus (Van den Berg 1988). Buffalo milk also contains more of the minerals sodium, chloride, magnesium and potassium (Tripaldi 2008).

The beta-carotene is better transformed into vitamin A in buffalo milk compared to milk from cattle. This makes the colour of buffalo milk whiter rather than yellowish. Moreover, the peroxidase activity is 2-4 times higher in milk from buffalo. Therefore, buffalo milk, compared with milk from cattle, can be preserved for longer time. Due to its higher dry matter content, the buffalo milk is preferably used for production of cheese, yoghurt, butter, cream, curd and powdered milk. Compared with milk from cattle, the buffalo milk gives a higher yield of all these products (Khan *et al.* 2017). Also, the required time for the manufacturing, as well as the cost, is lower when using buffalo milk in the dairy production. This fact makes the buffalo milk more attractive for dairy product manufacturers, and the farmer can thereby have a better profit when selling the raw material (Perera 2001)

1.3.3 Milk fat composition

When compared with cattle, buffalo milk contains more fat. Further on, the buffalo milk has a higher proportion of saturated fat, giving a higher melting point. It also contains a higher amount of palmitic-, stearic- and butyric acids, while containing less of the acids caproic, capric and caprylic. Due to more saturated fat, buffalo milk is less susceptible to oxidation than milk from cattle (Kashawa 2016). The main fat fraction both in buffalo- and cow milk consists of triglycerides. Interestingly, even if buffalo milk is richer in fat, the cholesterol levels are lower compared with milk from cattle. It only contains 275 mg cholesterol per kg while milk from cattle reaches 330 mg per kg. Also, the content of phospholipids is ower in buffalo milk (Elvingson 2013).

1.3.4 Milk protein composition

Milk consists of primarily six types of proteins, i.e. αs1-, αs2-, β-, κ-casein, α-lactalbumin and β-lactoglobulin. The four subtypes of casein, αs1-, αs2-, β-, and κ-casein, constitute 80 % of the total milk protein, and the remaining 20% is whey protein. αs1- and β -casein constitute the main fraction of protein in the milk (Van den Berg 1988). However, very few studies have been performed on the protein composition of milk from buffaloes (Bonfatti *et al.* 2013). The protein composition greatly affects the technological properties of the milk, as well as the nutritional value. A high proportion of casein will increase the dairy production yield, especially in cheese manufacturing. Also, coagulation and firmness of the curd in cheese making, are positively affected by casein (Heck 2009).

The protein concentration in buffalo milk is, as mentioned, higher than in milk from cattle. Moreover, the concentration of casein is also higher within the buffalo milk, with a casein index (content of casein/content of total milk protein x 100) higher than 80% (Tripaldi 2008). Also, in buffalo milk the casein micelles have a lower hydration level and a higher level of mineralization compared to milk from cattle. This gives the buffalo milk a higher content of minerals (Elvingson 2013).

1.3.5 Lactose content

The lactose, casually termed as milk sugar, is a disaccharide composed of glucose and galactose. Lactose in milk may be fermented by microorganisms, for example lactic acid bacteria (LAB). These bacteria convert lactose into lactic acid, a beneficial and preferable process in many dairy products (Van den Berg 1988).
The synthesis of lactose takes place in the Golgi apparatus of the alveoli. Due to the fact that lactose is the major osmotically active component and is responsible for drawing water into the milk, the concentration of lactose is the least variable of the milk components. (Lactation Biology Website 2010).

Buffalo milk consists of 4.8% lactose while, in cattle, the levels are slightly lower - 4.6% (Olsson 2007). The lactose content of milk will not, except in case of underfeeding of the animal or disease, vary very much. However, inflammation of the udder, known as mastitis, will decrease the lactose content and affect the milk yield in a negative way (Danielsson & Niva 2007).

1.4 Curd

Fermentation of milk is a beneficial process since it protects the food and enriches it with extra nutrients. In Sri Lanka, a large segment of the population consumes fermented dairy products, due to their better digestibility, organoleptic properties and nutritional value (Jayasinghe 2011).

Fermentation means that microorganisms, which are added in the manufacturing process, will ferment lactose to lactic acid, reducing the pH-value and thereby making the milk protein coagulate. LAB are the microorganisms giving the fermented milk products their special properties. One of all these beneficial fermented milk products, is curd. In Sri Lanka curd is served either without adding any extra additives, or with added sugar, salt, pepper or fruits. It is eaten mostly as a desert, but can be used in main courses as well (Disanayaka 2019). Sri Lankan curd is said to taste similar to plain yoghurt or Greek yoghurt. It is creamy and the taste is somewhat sour (Migrationology 2019).

1.4.1 Curd production

Curd is one of the oldest fermented milk products in Sri Lanka and is made both commercial and in households (Adikari *et al.* 2014). Curd can be made from both buffalo milk and cow milk. The buffalo curd is named *Meekiri*, and curd made of cow milk *Deekiri*. In the process of making curd, the lactose in the milk is converted into lactic acid by the added LAB. The lactic acid will reduce the pH of the milk and at the isoelectric point of casein, pH 4.6, coagulation of the milk occurs. In the process, either freeze dried starter cultures or an inoculant from previously made curd, can be added to the pasteurized milk (personal communication Disanayaka 2019).

1.4.2 Commercial curd manufacturing process in Sri Lanka

Producing curd is a simple process. A commercial, but still small-scale, production of curd can be performed as following: Buffalo milk is pasteurised at 92°C, during stirring, and kept at this temperature for 10 minutes. The temperature should then be reduced to 42°C, at which point a mesophilic starter culture is added to the milk. The milk is then poured into plastic pots or clay pots, where the fermentation and the coagulation take place and the curd is formed. The pots with milk should be stored at room temperature for about 24 hours, and thereafter stored at 4-6°C for 1-2 days. After coagulation the curd is ready to eat. In refrigerator (4-6°C) it has a shelf life of about 7 days and in room temperature the shelf life is decreased to 1-3 days (Vidyarathna 2019).

Buffalo milk is preferably used in the curd production, rather than milk from cattle. Because of the higher content of fat (Table 2), buffalo milk gives a higher yield of curd. However, the higher fat content in buffalo milk could result in an earlier spoiled product due to rancidity (Vidyarathna 2019).

1.4.3 Requirements of curd characteristics

Curd should have a pleasant odour and characteristic flavour. It should be produced in a clean environment, free from dirt and extraneous matter. The curd mass should be firm solid and free from lumps. The consistency should be uniform and with neglectful whey separation. No other preservatives than sorbic acid can be added to the curd, and not more than 1 g/kg. Also, curd should comply with the requirements specified in Table 2, where the required minimum fat content and total solids, as well as pH maximum, is stated for both buffalo- and cow products (Sri Lanka Standards Institution Standard 1988).

Table 2. *Requirements of curd, Meekiri compared to Deekiri, illustrated from Sri Lanka Standards Institution Standard 1988.*

Characteristics	Meekiri	Deekiri
Milk fat, percent by mass, minimum.	7.5	5.0
Milk solids (not fat), percent by mass, minimum.	8.5	8.5
pH-value, maximum	4.5	4.5

1.4.4 Syneresis and stabilisers

Syneresis in curd is explained as the expulsion of whey from the curd mass. Too much syneresis is unwanted, and therefore often controlled by adding stabilisers in the manufacturing process of milk products. Also, the stabilisers enhance the viscosity and the texture, as well as improve the creaminess and mouthfeel of the product. The most commonly used stabiliser is gelatine, which is of animal origin (Jayarathna 2013). Stabilisers are water soluble macromolecules forming three-dimensional gel networks in the milk, which traps the whey and increases the capacity of the curd to retain water. The stabilisers also interact directly with the proteins and thereby form a stable network. Milk products with lower total solids are more sensitive to syneresis than milk products with higher content of solids (Magdaleno Morales Henrysson 2016).

The manufacturing process of curd made of buffalo milk does not include any additives such as stabilizers. However, when using milk from cattle in curd production, stabilizers are advantageously added to increase the viscosity, thickness and creaminess of the curd. The reason for this is the lower fat content in milk from cattle, which has to be compensated (Vidyarathna 2019).

2 Material and methods

This Minor Field Project was performed between 25th of March and 20th of May 2019.

The main part of the study was carried out at Mawalawaththa Livestock Field station, part of the Department of Animal Science, University of Peradeniya, Sri Lanka. The field station is located in Peradeniya, a few kilometres outside the city of Kandy. The station includes a farm unit with 45 buffaloes, of which 6 were milking, and 50 cows, of which 18 were milking. It also includes a processing plant, where yoghurt, ice-cream and curd are produced, only using the buffalo- and cow milk from the local field station farm.

This project was divided into two parts. Part 1 was performed at the Livestock field station, where milk from buffalo and from European breeds of cattle was collected and analysed. Part 2 was performed partly at the processing plant, where both Meekiri and Deekiri was produced, partly at the Department of Animal Science, where the curd was evaluated considering appearance, odour, colour, texture, flavour and syneresis, with help of a test panel. The field visits at Mawalawaththa Livestock Field station were assisted by dairy assistant R.L.D. Sampath and farm manager C. Vidayarathna.

2.1 Part 1 – Comparison between the composition of milk from buffalo and European cattle

At the cattle and buffalo unit of Mawalawaththa Livestock Field station, three lactating buffaloes and six lactating European cattle were selected from the herd. The three buffaloes were of the breed Nilli-Ravi crosses, with a Nilli-Ravi father and Murrah mothers. Three of the European cattle were of Friesian breed, and the other three of Jersey breed. The Jersey breed was chosen because of the known high milk fat content, 4.9% and its high milk protein content, 3.8% (Petsonmom 2019). All nine animals were in the same lactation stage and fed the same feed, consisting of concentrate and pasture from grazing. However, the amount of feed varied as the buffaloes eats larger quantity than the European cattle (personal communication Sampath 2019).

2.1.1 Collection and analyses of milk samples

Early in the morning, at 05.30, the three buffaloes were milked by hand and the six European cattle were milked with a milking machine (personal communication Sampath 2019). Individual milk samples from each of the nine animals were collected in test tubes during the morning milking. The milk samples were then analysed using a Lactoscan SP60, which provides values of fat, SNF (Solids-Not-Fat), lactose and protein. The Lactoscan is based on high-end ultrasonic technology, with a principle of measuring the speed of the ultrasound in the milk. The pH-values of each milk sample was measured separately with a pH-meter at 27°C.

2.2 Part 2 – Comparison between Meekiri and Deekiri

At the processing plant of Mawalawaththa Livestock Field station, Meekiri and Deekiri were produced by milk from buffalo and European cattle, respectively. The two curds were both produced according to the manufacturing principle stated in paragraph 2.3.2 *Commercial curd manufacturing process in Sri Lanka*, without any additives, except for the starter culture. The milk was not homogenized before the curd production. Two days later both curds were transported to the Department of Animal Science at the University of Peradeniya, for further measurements and evaluations.

2.2.1 Sensory evaluation

The two days old curds were further evaluated. The sensory evaluation of Meekiri and Deekiri was performed as following: a panel of 31 judges, including students, professors and employees at the Department of Animal Science of the University of Peradeniya, were served curd samples for evaluation. Each person had one serving of Deekiri, one serving of Meekiri and a glass of water for rinsing between the two curd samples. Each judge was given a ranking card (see Appendix I) based on a one-to-five-point scale, where one was marked for “least preferred” and five for “most preferred”. The ranking system was used to observe the difference between the curd samples. The obtained data were edited, entered in a table and the mean values was calculated (see Appendix II)

2.2.2 Determination of syneresis

Two days after production, syneresis of Meekiri and Deekiri was measured according to a method described by Jayarathna (2013). For each curd the experiment was performed in triplicates. 10 grams of curd sample was spread in a thin layer onto a filter paper over a Buchner funnel. The funnel was arranged over an Erlenmeyer flask, which was connected to a vacuum pump. When the system was set and prepared, the curd sample was sucked under vacuum for 10 minutes. The whey in the flask was collected and weighed.

The syneresis percentage was calculated as following: (Weight of the liquid / Initial curd sample weight) x 100 = syneresis percentage (see Appendix III).

A mean value for the syneresis percentage of each curd was calculated, as well as standard deviation.

3 Results

3.1 Part 1 – Composition of milk from buffalo and European cattle

The average fat content of the three milk samples from buffalo was 7.44%. The average fat content of the three milk samples from Friesian and Jersey, was 4.04% and 5.03%, respectively. The fat content varied amongst the individuals. In buffalo milk, it varied between 6.54-7.90%. The fat content of the milk from Friesian and Jersey varied between 3.88-4.28% and 4.03-6.64%, respectively (Table 3).

The SNF content did not vary between the three milk samples, neither from buffalo, nor from the three Friesians. The SNF content varied amongst the three Jerseys from 7.23-8.88% (Table 3).

The protein content of all nine milk samples was on a fairly equal level, though generally a slightly higher amount of protein was observed in the buffalo milk. The protein content varied between 3.08-3.28% amongst the buffaloes, 2.60-3.23% amongst the Jerseys and was on a stable level at 2.98% amongst the Friesians (Table 3).

The lactose content did not vary much between the three milk samples from buffalo, and not amongst the three Friesians. Within the three milk samples from Jersey, the lactose content varied between 3.95-4.87% (Table 3).

Only a small pH variation was observed, pH varying between 6.20 and 6.37 in milk from the nine animals (Table 3).

The milk fat content showed the largest variation between the three different animal breeds. Milk from the nine animals showed only small variation in SNF, protein and lactose content.

Table 3. *Milk composition of nine different milk samples collected from buffalo, Friesian and Jersey breeds, Mawalawaththa Livestock Field station. Solids-Not-Fat = SNF*

Animal breed	**Individual number**	**Fat (%)**	**SNF (%)**	**Protein (%)**	**Lactose (%)**	**pH**
Buffalo	**23**	7.87	8.56	3.08	4.68	6.20
Buffalo	**07**	6.54	9.01	3.26	4.93	6.21
Buffalo	**06**	7.90	9.12	3.28	4.98	6.33
Friesian	**1508**	3.97	8.19	2.98	4.49	6.20
Friesian	**1511**	4.28	8.20	2.98	4.49	6.25
Friesian	**1211**	3.88	8.20	2.98	4.49	6.29
Jersey	**1201**	4.43	8.19	2.97	4.48	6.35
Jersey	**1419**	4.03	8.88	3.23	4.87	6.30
Jersey	**1005**	6.64	7.23	2.60	3.95	6.37

3.2 Part 2 – Sensory evaluation of Curd

The two curds Meekiri and Deekiri were successfully produced with firm texture free from lumps. The visual appearance was that Meekiri was whiter in colour, while Deekiri had a distinct yellow colour (Image 1). Also, the texture was different between the two curds. Meekiri was slightly firmer than Deekiri. Both curds had a fat layer on the top, though it was double as thick in Meekiri. The taste of Meekiri was sourer while Deekiri had a milder flavour. After three days in refrigerator, Meekiri was still firm and solid while the texture of Deekiri had begun to burst and crack (Image 2).

Image 1. Appearance of *Meekiri (to the left) and Deekiri (to the right) one day after production. (Photo: Jennifer Hallqvist, 2019)*

Image 2. *Appearance of Meekiri (to the left) and Deekiri (to the right) three days after production. (Photo: Jennifer Hallqvist, 2019)*

3.2.1 Sensory evaluation of Meekiri and Deekiri

The sensory evaluation of Meekiri and Deekiri displayed some differences between the two curd samples. In average, Meekiri was ranked slightly higher than Deekiri in all perspectives (Figure 1).

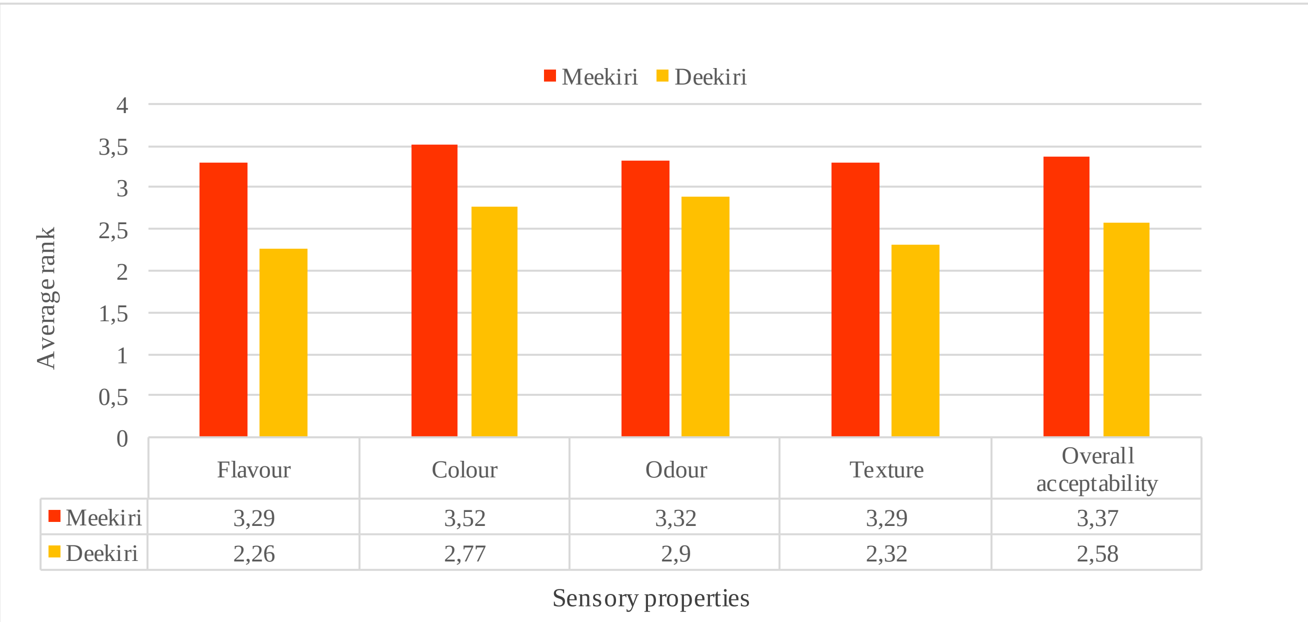

Figure 1. *Estimated mean values for each sensory attribute in a comparison between Meekiri and Deekiri, calculated from the sensory evaluation performed at the Department of Animal Science, University of Peradeniya, 2019*

3.2.2 Syneresis percentage of Meekiri and Deekiri

The determination of syneresis in Meekiri and Deekiri showed differences between the two curd samples. Meekiri had an average syneresis of 39.67%, and Deekiri had an average syneresis of 65.13%. However, sample 3 of Meekiri is an obvious outlier in comparison to the other two samples (Table 4).

Table 4. *Syneresis (%) of Meekiri and Deekiri in triplicates. Standard Deviation = SD*

Curd product type	Sample 1	Sample 2	Sample 3	Average syneresis +/- SD
Meekiri	48.16	46.69	24.15	39.67 +/- 13
Deekiri	67.17	64.47	63.74	65.13 +/- 1,8

4 Discussion and conclusion

The analyses of Buffalo milk and milk from cattle showed as predicted a clear variation in fat content. As expected, the buffalo milk had the highest fat content followed by the milk from Jersey cows. This result agrees with earlier research (Kashawa 2016). The other components did not vary that much in between the three breeds. The buffalo milk showed a slightly higher protein content, but the difference was not as high as expected. The protein content was generally somewhat low in the milk samples from all nine animals, which probably is connected to seasonal differences and current milk yield. The lactose content was, as expected, less variable than the other milk components, and the pH values were all somewhat low for milk samples. The results confirmed the hypothesis, i.e. the buffalo milk had a generally higher content of fat, protein, lactose and solids-not-fat than the European cattle breeds. This result agrees with earlier knowledge about the composition of buffalo and cow milk (Olsson 2007).

The variation in milk composition between different animal breeds and within individual animals can be a result of genetic variation, seasonal variation, different feed as well as the climatic impact. Buffaloes do manage very hard nutritional condition as well as less beneficial management. At certain places, for example in Sri Lanka, it is beneficial to use the buffalo as a dairy animal because of their acceptability to these hard conditions. However, the silent heat of buffaloes indirectly affects their milk production in a negative way, and could be a problem in a tropical country as Sri Lanka. Also, the reason for not using dairy buffaloes in for example Scandinavia, could be because of their low ability to adapt in truly cold climate.

The characteristics of Meekiri and Deekiri were, as expected, somewhat different. Meekiri matched the required curd characteristics with its firm solid texture and white colour. Though, in the sensory evaluation there were some split opinions about the curd properties. Some people preferred the mild flavour of Deekiri, as well as its yellow colour and less firm texture. This is because all people do not share the same taste for curd. Also, some of the judges were probably not aware of the required properties of curd and ranked only by their personal preference, while others ranked with knowledge of what characteristics a curd is supposed to have. Due to this, the hypothesis was only partly confirmed. Meekiri did not outshine Deekiri in all perspectives according to all judges. Nevertheless, the average result showed a slightly higher ranking for Meekiri after all. The variation in the sensory evaluation could have been avoided if all the judges had been informed in beforehand about what characteristics a good curd should have.

The stated hypothesis, that Meekiri should have a lower percentage of syneresis than Deekiri, showed to be true. However, the high standard deviation of the three Meekiri samples was a result caused by one deviant value, probably due to some kind of weighing error. With no doubt the lower syneresis is because of the higher fat and total solid content of Meekiri compared to Deekiri. These naturally occurring components work as stabilizers in the curd, lowering the expulsion of whey from the curd mass. Because of this, Meekiri is made commercially without any additives, while commercial made Deekiri most often contains additives such as gelatine. Commercial made Deekiri, found in the Sri Lankan food markets, can therefore be hard to distinguish due to the effect of the additives. It has the similar creaminess and firm texture as Meekiri.

The results from this study indicates that buffalo milk has a higher content of fat, protein, lactose, vitamins and minerals (solids-not-fat) than milk from cattle. This fact has increased the interest of research in the field of buffaloes. It is known that the buffalo is important as a production animal in big parts of Asia, Sri Lanka included. But, compared with developed dairy breeds e.g. Friesians and Jersey, the buffalo is not bred selectively for as many generations (Thomas 2004). However, the potentials of buffaloes are not yet fully utilized and the animal has much to offer if more people get knowledge about this outstanding breed (Ménard 2010). The Sri Lankan curd is a product relying on buffalo farming. Curd is not yet very well known in the western world, for example in Scandinavia, due to the lack of buffaloes in this area. The priority of this study was to investigate and collect information about buffaloes as a dairy animal in Sri Lanka and its importance in the curd manufacture of the country.

This was a small study including only three buffaloes, which could have had an impact on the results due to the impact of individual variation. An improvement of this current study should include more animals, continue for a longer time and be analysed statistically. Further studies could investigate seasonal variation in milk composition, variation in milk composition between different buffalo breeds and how milk yield of buffaloes is affected by environmental factors, e.g. heat. The high level of total solids, in particular caused by the high fat content, makes buffalo milk ideal for further processing into valuable dairy products, such as cheese. The buffalo milk is spread mostly throughout Asia, due to the climate suitable for buffalo breeding. It would be very interesting to investigate the possibilities of using buffalo milk in a broader perspective, all over the world. Further studies about production value and shelf life could increase the knowledge and interest of raw buffalo milk, even outside of Asia.

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Appendix

Appendix I. Ranking Card used in the sensory evaluation of Curd made by using Buffalo milk and milk from cattle, 2019

Ranking Card
Sensory evaluation of Curd made by using different milks

Date - ……………………………….…

Name - ………………………………

Gender - Male / Female

Age - ……………………………….……..

Please taste two given curd samples and rank them by using following attributes and numerical values for given characteristics.

Attribute	**Ranks**
Least preferred	1
	2
	3
	4
Most preferred	5

Instructions

- You are kindly requested to taste each two given curd samples, which are presented with the two codes A and B, and rank the flavour
- Rank the other qualities by observing the curd samples
- Wash your mouth after each attempt

Code	**Qualities of curd**					**Remarks**
	Flavour	**Colour**	**Odour**	**Texture**	**Overall Acceptability**	
A						
B						

Comments/ Impressions

……………………………….……….……….……….……….……….……….……….……….……….………
……………………………….……….……….……….……….………

……………………………….…….
Signature

Thank You!

Appendix II. Obtained data from the ranking cards of 31 judges in the sensory evaluation of Meekiri and Deekiri, and average values for each sensory property, 2019

Code A / Deekiri	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
Flavour	3	2	2	4	3	3	1	1	2	1	4	1	1	2	1	1	1	4	3	2	2	3	4	1	2	2	2	4	4	2	2	2,258065
Colour	2	1	5	2	3	2	3	1	2	2	3	4	2	2	5	2	2	4	2	3	3	2	5	5	2	2	2	4	4	2	3	2,774194
Odour	4	2	2	3	4	3	4	2	4	5	3	3	2	2	3	1	3	4	4	2	3	2	2	4	4	2	2	4	5	1	1	2,903226
Texture	2	2	2	2	4	1	4	1	2	3	3	4	2	1	5	3	1	4	3	2	2	1	2	3	1	2	2	2	4	1	1	2,322581
Overall Acceptability	3	2	1	4	4	2	3	1	2	2	3	4	2	2	4	1	2	4	3	3	2	1	5	3	1	2	2	4	4	2	2	2,580645
Code B / Meekiri																																
Flavour	2	1	2	2	4	4	4	5	4	4	3	2	2	4	4	3	4	1	4	4	4	3	2	3	5	4	4	2	5	4	3	3,290323
Colour	3	1	2	4	4	5	4	5	5	5	4	2	1	5	3	1	5	3	4	4	5	4	2	3	4	4	5	3	3	5	1	3,516129
Odour	2	1	4	2	5	5	3	4	3	5	4	2	1	4	5	2	5	1	5	4	4	3	2	3	4	3	5	2	3	5	2	3,322581
Texture	3	1	5	4	4	5	3	5	2	4	5	3	1	3	2	2	4	3	4	5	4	3	2	3	2	3	5	4	2	3	3	3,290323
Overall Acceptability	2	1	5	3	4,5	5	4	5	4	4	4	3	1	4	3	2	5	1	4	4	4	3	2	4	2	4	5	2	3	4	3	3,370968

Appendix III. Calculations of syneresis percentage of Meekiri and Deekiri from the determination of syneresis, 2019

Meekiri

1. (4,8444g/10,0599g) x 100 = 48,16 %
2. (4,6843g/10,0321g) x 100 = 46,69%
3. (2,4161g/10.0057g) x 100 = 24,15%

39,67%

Deekiri

1. (6,7431g/10,0389g) x 100 = 67,17%
2. (6,4523g/10,0088g) x 100 = 64,47%
3. (6,4226g/10,0756g) x 100 = 63,74%

65,13%