The production of colostrum from a feeding perspective

Produktionen av råmjölk från ett utfodringsperspektiv

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Abstract

Feeding good quality colostrum to newborn calves is essential to ensure their health and survival. Therefore, it is important to ensure production of enough yield and good quality colostrum in dairy farms. Some factors that have been shown to affect the quality of colostrum such as parity and time to first milking after calving. However, information about the effects of different dry period feeding strategies on colostrum production is lacking. For this reason, the purpose of this study was to investigate the effects of two different feeding strategies during the dry period on colostrum production and calf health. This study was a field study, data were collected from 20 Swedish farms that were selected according to their feeding strategy: a) total mixed ration (TMR) or b) separate feeding. Data were collected over a 2-month period and included a questionnaire and a visit to each farm. Colostrum yield was registered from 454 cows and the yield ranged from 0.02 to 25 litres the first milking (average 5.1 litres). The results showed that the feeding strategy had no effect on yield of colostrum produced. The quality of the colostrum measured by a Brix refractometer ranged from 11 to 40 % (average 23.6%). Cows fed a TMR diet tended to produce slightly higher quality (24.1%) colostrum than separate feeding cows (22.9%). So many as 26% of the colostrum samples were below the recommended Brix value of 22%, that could ensure calves adequate intake of immunoglobulins. Sixteen of the 20 farms had a strategy to give newborn calves colostrum with a minimum Brix value. Cow parity affected colostrum yield were older cows produce higher yield of colostrum (6 litres) compared with primiparous cows (3.4 litres). In this study 13% of the cows yielded only 1 litre or less in the first milking, which is worrying. The time from calving to first milking affected the quality of colostrum, quality decreased with increased time interval. A higher proportion of calves born to separate fed cows had higher vitality score than calves from TMR cows. Feeding strategy did not affect calf birth weight or calf body temperature at birth. The comparison between TMR and separate strategies should be interpreted with caution due to limitations in the study design such as relatively few farms, unbalanced numbers, differences between individual farms in feeding management strategies and differences in management practices around calving in general.

Keywords: Colostrum, calf health, dry cows, feeding

Sammanfattning

Utfodringen av råmjölk av god kvalitet till nyfödda kalvar avgörande för att säkerställa deras hälsa och överlevnad. Därför är det viktigt att säkerställa produktion av god råmjölkskvalitet inom mjölkbesättningar. Vissa faktorer som har visat sig påverka kvaliteten på råmjölken är kalvningsnummer och tid till första mjölkning efter kalvning. Men information om vad olika foderstrategier under sinperioden har för effekt på råmjölksproduktionen saknas. Av denna anledning var syftet med denna studie att undersöka effekterna av två olika utfodringsstrategier under sinperioden på råmjölksproduktion och kalvhälsa. Denna studie var en fältstudie, data samlades in från 20 svenska gårdar som valdes ut enligt deras utfodringsstrategi: a) fullfoder (TMR) eller b) separat utfodring. Data samlades in under en tvåmånadersperiod och inkluderade ett frågeformulär och ett besök på varje gård. Råmjölksavkastningen registrerades från 454 kor och avkastningen varierade från 0,02 till 25 liter den första mjölkningen efter kalvning (genomsnitt 5,1 liter). Resultaten visade att utfodringsstrategin inte hade någon effekt på råmjölksavkastningen. Kvaliteten på råmjölken mättes med en Brix-refraktometer, varierade från 11 till 40% (genomsnitt 23,6%). Kor som utfodrades en TMR-diet tenderade att producera råmjölk av högre kvalitet (24,1%) än separat utfodrade kor (22,9%). Så många som 26% av råmjölksproverna var under det rekommenderade Brixvärdet på 22%, vilket skulle kunna säkerställa kalvarna tillräckligt utbyte av immunglobuliner. Sexton av de 20 gårdarna hade en strategi att ge nyfödda kalvar råmjölk med ett minimum av Brix-värde. Antal kalvningar som kon fått tidigare påverkade råmjölksavkastningen där äldre kor producerar en större mängd råmjölk (6 liter) jämfört med förstakalvare (3,4 liter). I denna studie mjölkade 13% av korna endast 1 liter eller mindre den första mjölkningen, vilket är oroande. Tiden från kalvning till första mjölkning påverkade råmjölkens kvalitet, kvaliteten minskade med ökat tidsintervall. En högre andel kalvar födda för att separera utfodrade kor hade högre vitalitetspoäng än kalvar från TMR-kor. Utfodringsstrategin påverkade inte kalvfödelsevikt eller kalvkroppstemperatur vid födseln. Jämförelsen mellan TMR och separata strategier bör tolkas med försiktighet på grund av begränsningar i studiens design, såsom relativt få gårdar, obalanserat antal, skillnader mellan enskilda gårdar i strategier för utfodringshantering och skillnader i management kring kalvning i allmänhet.

Nyckelord: Råmjölk, kalvhälsa, sinkor, utfodring

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Abbreviations

BCS	Body condition score
CAD	Cation-anion difference
CP	Crude protein
DM	Dry matter
FPT	Failure of passive transfer
Ig	Immunoglobulins
NDF	Neutral detergent fiber
PMR	Partial mixed ration
TMR	Total mixed ration

1. Introduction

Colostrum is important for all mammals. Colostrum supply the new-born with essential nutrients, such as, proteins vitamins and fat (Sjaastad *et al.,* 2016). In addition, antibodies (immunoglobulins) from the cow are transferred to the calf exclusively through colostrum. Antibodies are essential to fight disease and it is therefore very important that the calf gets colostrum of good quality soon after birth to protect the calf against microorganism present in the local environment. Therefore, it is crucial that cows are able to produce good quality colostrum and in sufficient yields to feed the new-born calf. Many factors can affect colostrum production and colostrum quality. For example, nutrition, age, season and time to first milking after calving (Conneely *et al.,* 2013; Dunn *et al.,* 2017; Denholm *et al.,* 2018).

Colostrum is produced only during the final weeks of pregnancy (Sjaastad *et al.*, 2016) and this period coincides with the dry period. Therefore, good nutrition during the dry period is essential for ensuring good colostrum production and quality. However, there are just a few studies reported in the literature about dry cow feeding, and how it affects colostrum production is with some finding effects of diet on colostrum IgG content (Mann *et al.,* 2016) while others find no effect (Dunn *et al.*, 2017).

Furthermore, there are no clear recommendations regarding cow feeding during the dry period and in many farms, it is still a common belief that dry cows do not need the same high-quality feed as lactating cows (in terms of energy and protein content). Differences in feeding strategy could influence the yield and quality of colostrum produced.

Therefore, the aim of this study was to compare farms with two different feeding strategies during the dry period, TMR or separate feeding, and asses their effects on colostrum quality and yield, calf birthweight, health and vitality on farms. Also, Lindqvist (in press) studied dry cow feeding, diet composition and milk fever incidence on the same farms.

2. Literature review

2.1. Colostrum

2.1.1. Colostrum composition

Colostrum composition is different from regular milk mainly in terms of protein (due to increased immunoglobulins) and fat content (Sjaastad *et al.,* 2016). Purpose of producing colostrum is to protect the new-born calf from infection and mortality. Colostrum contains more energy, protein, fat, minerals and vitamins than regular milk, (Table 1) shows contents of colostrum compared to transitional milk and regular milk.

Table 1. Nutrient composition (g/L) of colostrum, transition milk and regular milk in dairy cows. (Sjaastad et al., 2016. Lindmark-Månsson et al., 2003)

	Colostrum at parturition	After 24	Regular milk	Dairy milk[1]
Total solids	260	170	128	132
Proteins	180	82	33	34
Lipids	50	40	38	43
Lactose	20	40	50	46
Ash	10	8	7	7
Total Ig	130			

Accumulation of immunoglobulins in the mammary gland occur when immunoglobulins are taken from maternal blood by receptor-mediated endocytosis and then they are transferred through the mammary epithelial cell into the milk (Sjaastad *et al.,* 2016).

Calf receives vitamin E directly from colostrum since it is poorly transported via placenta (Suttle, 2010). Cows blood plasma concentration of vitamin E decreased around calving due to colostrum and secretion (Goff & Stabel, 1990). In the study by Goff and Stabel (1990) plasma concentration of vitamin E decreased by 53% at calving from prepartum baseline, and baseline value was an average value of plasma concentration at 14, 10 and 7 days before calving. Therefore, it is important to ensure that dry cow receive enough vitamin E during dry period recommended is 1.6 (IU/kg BW) (Nielsen & Volden, 2011). For new-born calf it is also a risk with low intake of vitamin E when it increases the risk for selenium loss which in turn can cause the calf to become slow and not able to suckle like it should (Suttle, 2010).

Even zinc (Zn) concentration is decreasing in cows blood plasma around calving due to the fact that it accumulates in colostrum (Suttle, 2010; Goff & Stabel, 1990). Plasma Zn concentration decreases by 22% at calving compared to baseline value. Lowest value of Zn concentration in plasma is found 1 day after calving but quickly returns to baseline value 3 days after calving (Goff & Stabel, 1990). Zinc deficiency can lead to limitations in health and production, examples are the effect on appetite, fat absorption and antioxidant defences (Suttle, 2010).

Selenium is important for antioxidant and thyroid hormone function as it is an essential trace mineral (Rowntree *et al*., 2004). Selenium concentration decrease in colostrum compared to regular milk (Suttle, 2010). It is possible to raise concentration with Se in colostrum and in calf serum with supplementation of Se during dry period (Rowntree *et al*., 2004).

As previously mentioned, colostrum contains a higher content of minerals than regular milk. Kume and Tanabe, (1993) have studied mineral content in colostrum for cows in 4th lactation and how it is changing in time and result is shown in (Table 2). Kume and Tanabe, (1993) mean that can indicate that mineral need for the dry cow increased markedly at birth due to transfer to colostrum.

Table 2. Colostrum yield and mineral changing over time Kume and Tanabe, (1993)

Time after calving (h)	0	12	24	72
Colostrum yield (kg/day)	11.7[1]	-	14.9[2]	21.6[3]
Ca (g/l)	2.09	1.68	1.43	1.25
P (g/l)	1.75	1.43	1.25	1.01
Mg (g/l)	0.31	0.21	0.15	0.11
Na (g/l)	0.69	0.64	0.58	0.53

[1] During 0 to 24 h postpartum

[2] During 24 to 48 h postpartum

[3] During day 3 postpartum

2.1.2. Immunoglobulins

Colostrum contains a higher yield of proteins than regular milk, the increase in proteins is mostly due to immunoglobulins IgG, IgM and IgA. Of total 180 g/L protein concentration immunoglobulins represent 130 g/L (Sjaastad *et al.,* 2016).

IgG is the immunoglobulin that is produced in largest quantity, approximately up to 80% of total immunoglobulins. For cattle IgG is divided into three subclasses, IgG_1, IgG_2 and IgG_3 but only IgG_1 and IgG_2 are represented in colostrum but IgG_1 dominates (Farrell *et al.*, 2004). Together with IgM, IgG is the one that is responsible for defence against bacteria, bacterial toxins and some types of viruses. IgA is responsible to protect internal organ from invading microbes, IgA is transferred to epithelial cells of mucosal membranes acts as a defence. It is difficult for the farmer to measure concentration of IgG in colostrum at the farm, instead a Brix refractometer could be used and measuring the refractive index of solutions which can estimate concentration of total solids in colostrum, this method has been highly correlated with IgG concentration in colostrum (Buczinski and Vandeweerd 2016) and the equation is IgG (g/l) = -61.896 + 5.666 x Brix% (Quigley *et al.*, 2013). On a Brix refractometer scale 50g/L is 22% in Brix %, that indicate that colostrum has to reach 22% or higher in Brix to meet criteria for high quality in colostrum (AHDB Dairy, 2015). A calf should receive a daily yield of colostrum corresponding to 15% of the birth weight, for a calf weighing 40 kg it corresponds to 6 liters. For best absorption, it should be distributed over several meals during the first 24 (Kalvportalen, 2019d).

2.2. Dry cow feeding

2.2.1. Effects on colostrum

Diet and feeding strategy during dry period can affect colostrum production. For example, in a study comparing cows that were fed either a TMR or grass silage (same grass silage fed in TMR) found that TMR fed cows had a higher colostrum yield (7.48 litres than the silage diet 7.1 litres the first milking) but without affecting colostrum IgG concentrations (Dunn *et al.*, 2017). In another study there was no difference in colostrum yield (5.94 to 7.27 kg) between three different energy diets and feeding strategies: cows fed 1) a diet that met energy requirements during the total dry period of 57 days, 2) diet with 150% energy requirements and 3) same diet as first group for 29 days followed by diet with 125% of energy requirements from 28 days expected calving until parturition (Mann *et al.*, 2016). However, cows that were fed diet 1 that met energy requirements during the 57-day dry period resulted in a higher concentration of IgG (96.1 g IgG/L) in colostrum than in cows that received a diet with 150% energy requirements (72.4 g IgG/L) (Mann *et al.*, 2016).

In another study, a feeding strategy 7+1, 7 weeks far off and 1 week close up were tested, were a low energy content was fed to the cow (0.61 french feeds unit (UFL)/kg DM, NDF 56%) results in a higher concentration of IgA in colostrum compared to dry cows that were fed with a higher energy content (0.69 UFL/kg DM, NDF 52%) (Nowak *et al.,* 2012a). However, there was no difference in total immunoglobulins content, IgG or IgM, in colostrum between different feeding strategies.

Diets with increased protein (145-151) g/kg DM) promote better colostrum Ig yield. For example, multiparous cows that were fed with grass silage (145-151 g CP/kg DM, *in vitro* DM digestibility 63-65 *ad libitum* and 60 g mineral and vitamin supplement prepartum had a significantly higher total Ig yield at first milking colostrum than multiparous cows fed straw (65 g CP/kg DM; *in vitro* DM digestibility 44-61) *ad libitum* and 60 g mineral and vitamin supplement 15 days prepartum. The first milking after calving the silage fed cows yielded 4.5 L colostrum with 206 g Ig/L and the straw fed cows 3,9 L and 196 g Ig/L (McGee *et al.*, 2006). In addition, newborn calves fed colostrum 50 mL per kg birth weight had higher serum Ig concentration when they got colostrum from cows fed grass silage than from those fed straw. The concentrations in the calves' blood serum were 53 mg/L and 47 g/L, respectively, 8 h after birth, significant difference remained also after 48 h. Grass silage contained almost twice as much protein then straw. Before the last 15 days before calving, cows ate same grass silage as the other group. Toghyani & Moharrery, (2015) however, discovered that colostrum density was significant lower for cows that had received a higher level of CP (142 g CP/kg DM, 3,6 MJ NE/kg DM) during dry period, it was 0.38% lower density than for cows that received a moderate level CP (119 g CP/kg DM and same energy content) during dry period. Colostrum concentrations of IgG, fat, protein, lactose and solids not fat was not affected by CP level in the diet prepartum (per litre 68-69 g IgG, .77-80 g fat, 121-133 g protein, 28-30 g lactose)

A normal way to divide the dry period is by far-off and close-up period, normally where the far-off period is the first 4 to 6 weeks and close-up the last 3 weeks before calving (Dann *et al*., 2006). It is also common to adjust the feed state based on these periods. Dry cow feeding during the far-off period with a TMR feeding strategy *ad libitum* (2% of the body weight) was compared with dry cows that was fed the same TMR restricted (1.5% dry matter intake of body weight) during the far-off period, the average daily DM intake for the groups was 12.9 kg for the *ad libitum* group and 9.9 kg for the restricted group. Calves that had mothers that were fed *ad libitum* had significantly lower blood serum concentration of Ig, at 21 day postpartum of total immunoglobulins, IgG and IgM compared to calves that had mothers that were restrictedly fed (Nowak *et al.,* 2012b). The difference did not remain between any of the immunoglobulins after three days.

Stockdale & Smith (2004) compared two close-up diets the last 3-4 weeks before expected calving: TMR maize silage, barley, hay and pellets) and TMR supplemented with extra 3.5 kg soybean meal to thin dry cows (average BCS was 3.9 on a 8-point scale). Feeding just TMR resulted in lower IgG in colostrum the first milking than TMR supplemented with soybean meal (23 and 31 mg/kg, respectively). Level of cation anion difference (CAD) in dry cow feed had effect on colostrum yield. For example, a less (-70 mEq/kg DM) negatively level of dietary CAD during 21 or 42 last days prepartum had a significantly higher colostrum yield than a more (-180 mEq/kg DM) negatively level of dietary CAD during same period (Lopera *et al.,* 2018). Dry cow that received -70 mEq/kg DM significantly secreted more Ca and Mg to colostrum compared to dry cows that received -180 mEq/kg of DM. There was no difference in colostrum yield or concentration and concentration of composition due to the duration of feeding21 or 42 days prepartum.

2.2.2. Body condition score

BCS had effect on colostrum quality. Shearer *et al*. (1992) found that dry cows with BCS 3 (on a 5-poiunt scale) had an increased risk of low IgG (less than X g/L) in colostrum than thinner cows with BCS of 2.5. In the study they also measured body condition score at dry off and at calving, so it was possible to see if the cow had increased or decreased in body condition during dry period. Dry cow that had gained body condition during dry period had a significantly higher Ig concentration in colostrum compared to dry cows that lost in body condition. There was no difference between dry cows that lost body condition and dry cows that remained stable during the dry period.

2.3. Other factors affecting colostrum quality

In addition to nutrient supply to dry cows, also parity and time to first milking after calving can affect colostrum production and colostrum quality (Dunn *et al.*, 2017; Denholm *et al.,* 2018).

2.3.1. Parity

Cows parity has a positive correlation with Ig concentration in colostrum, see figure 1.

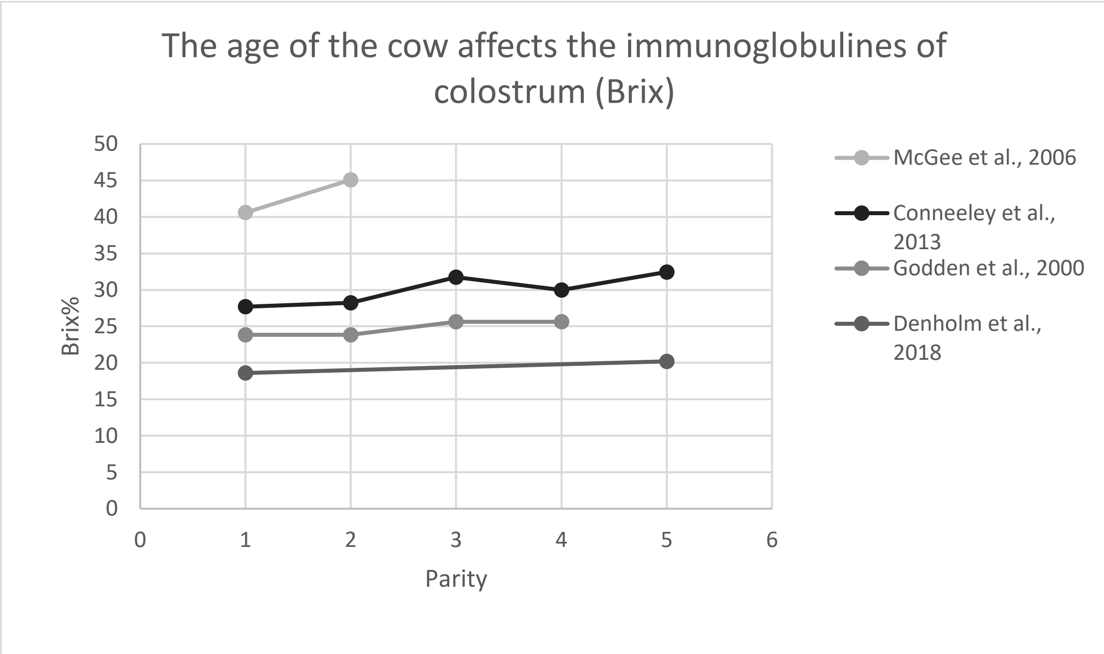


Figure 1. Relationship between parity and colostrum quality (measured as Brix%).

Denholm *et al*. (2018) found that older cows produce colostrum with a higher mean Brix value than samples from 2-year-old cows (Denholm *et al*., 2018). Cows in their first lactation had significantly lower Ig concentration in colostrum than for cows that had accomplished two or more lactations (Shearer *et al*., 1992). Cows in third lactation had a significantly higher concentration of Ig in colostrum compared with cows in second lactation. With increasing age, also concentration of Ig is increasing until it reaches a top at fourth lactation or older. Multiparous cows (average lactation number 6) had a significant higher total Ig concentration at first milking of colostrum than primiparous cows (McGee *et al*., 2006). This, Godden (2008) argues, is probably due to older animals having and greater exposure to local pathogens.

It is not just quality of colostrum that is affected by the age of the cow, multiparous cows with an average lactation number 6 had a significantly higher colostrum yield than primiparous cows that received same diet, see figure 2 (McGee *et al*., 2006).

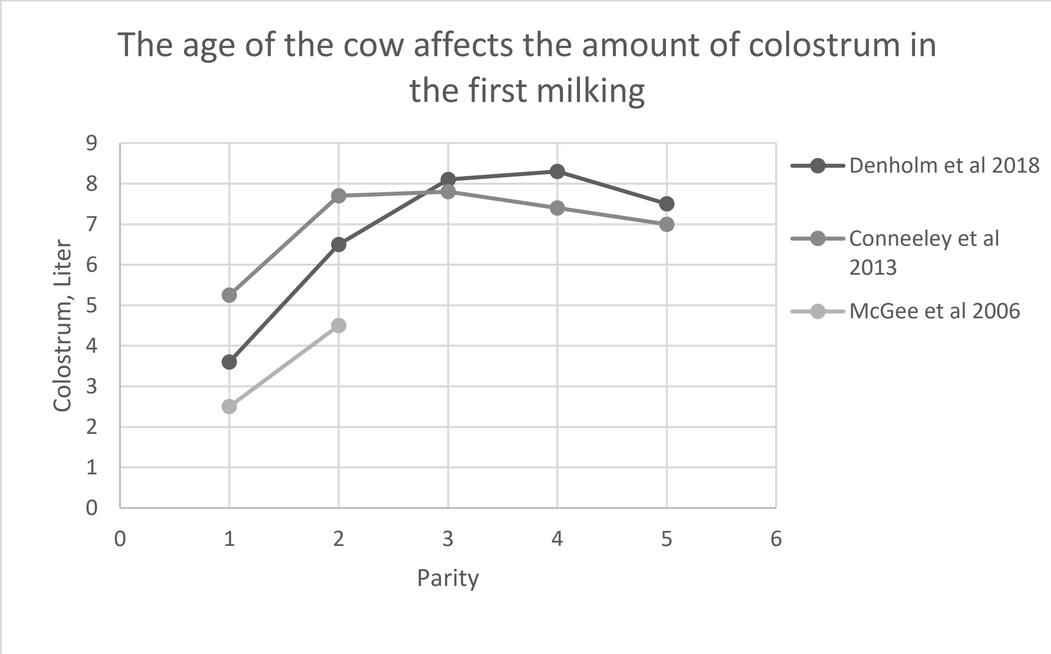


Figure 2. Relationship between parity and colostrum yield.

De Haan, (2018) found large variation in colostrum quality on three Swedish farms from 6.5 to 37.1 Brix %, where only 43% of the samples were above 22 Brix %. De Haan also found that Holstein cows had higher colostrum quality than Swedish red breed (SR). In the study, first milking was divided into 0-2 h, 2-5 h and more than 5 hours after calving. The proportion of colostrum with more or equal to 22 Brix% decreased with longer time from calving.

2.3.2. Delayed colostrum milking

Concentration of IgG in colostrum is influenced by, among other things, time of first milking. In other words, increasing time from calving to first milking affects quality of colostrum negatively (Moore *et al.*, 2005; Conneeley *et al*., 2013; Dunn *et al.*, 2017). Milking 2 h after calving leads to a significantly higher concentration of IgG in colostrum compared to collecting colostrum 6, 10 and 14 h after calving, see figure 3 (Moore *et al.,* 2005).

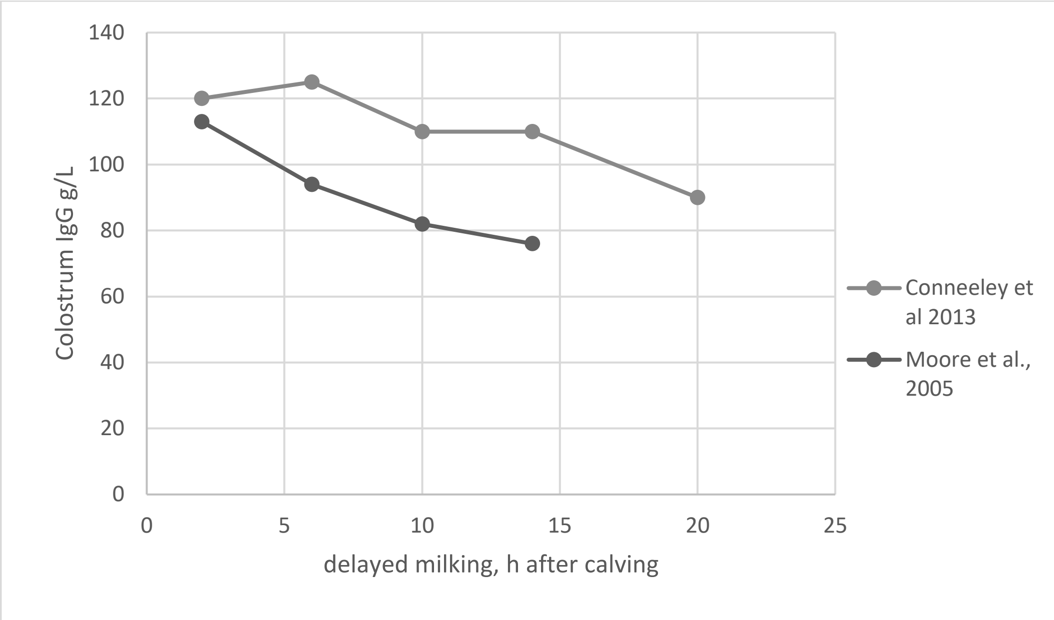


Figure 3. Effect of time to first milking after calving on IgG concentration.

In addition, IgG concentrations decrease rapidly from first milking on day one to third milking on day two by as much as 56% of IgG in first colostrum, see figure 4 (Dunn *et al.*, 2017).

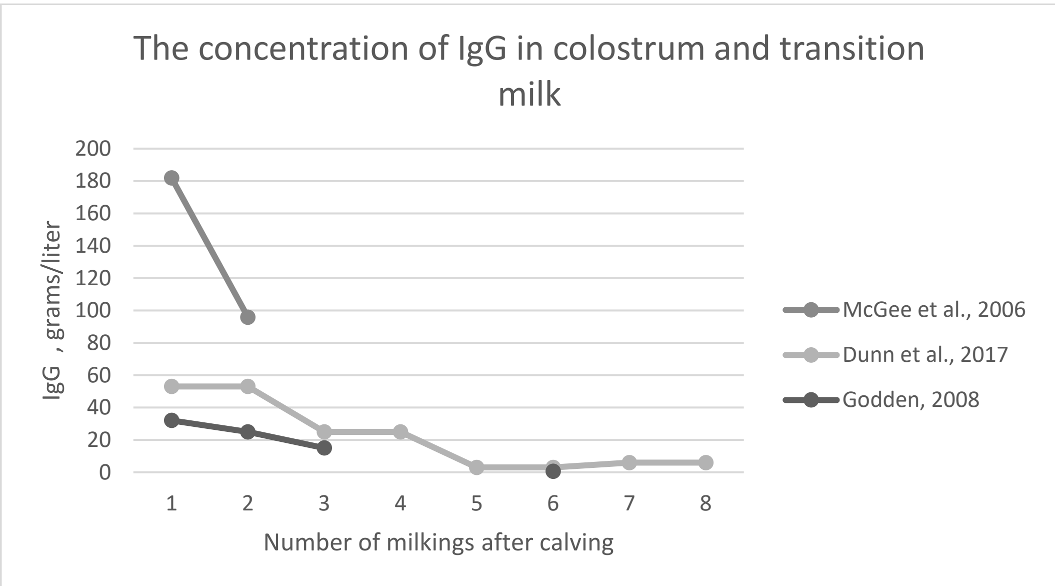


Figure 4. Ig in colostrum and transition milk.

There may also be differences within same milking. For example, three samples of colostrum were collected from first milking, first pre-milking then bucket-milk and last post-milking, pre-milking sample and post-milking sample were collected by hand milking and bucket-milk were collected by machine milking. Post milking sample of colostrum containing a significant lower yield of IgG than premilking sample and bucket sample (Hostetler *et al.,* 2003).

2.4. Calves

Dry cow feeding has not been shown to have any effect on calf birth weight. Protein level (Carstens *et al.,* 1987), energy level (Nowak *et al*., 2012a), restricted vs ad *libitum* feed (Nowak *et al.,* 2012b) and concentrate supplementation (Dunn *et al.,* 2017) were factors that have been shown not to give any difference in birth weight of the calf.

However, Nowak *et al*. (2012a) found that there was a significant difference in daily weight gain. Calves that had a cow that was fed a low energy content diet (0.61 UFL/kg DM) during dry period had lower average daily gain than calves that had a cow that was fed a high energy content diet (0.69 UFL/kg DM) during dry period. Difference between diets was 131 g in average daily gain of the calves (165 and 296 g daily gain per day, respectively). Concentrate supplementation during dry period had not same effect on daily gain for the calf (Dunn *et al.,* 2017).

Normal body temperature of newborn calves is between 39-39.5°C (Kalvportalen, 2019a). With difficult calvings can the body temperature rise and then decrease. Wind, draught, starvation and a damp fur could also cause cooling. A body temperature below 38°C can be considered critical. Birth body temperature of calves was not affected by dietary CP level to the mothers the last trimester of dry period according to Carsten *et al.* (1987). Calves that were born from cows that received high level of CP dietary (142 g/kg DM; 15.1 MJ NE/kg DM) during dry period had numerically higher serum IgG concentration at 72 h and significantly higher at day 21, than calves that were born from cows that have received a moderate level of CP (119 g/kg DM; 15.1 MJ NE/kg DM) in diet during dry period (Toghyani & Moharrery, 2015). Serum IgG concentration at 21 days age of the calf was significantly higher for calves that had a cow that received a higher level of CP in diet during dry period than calves from cows that received a moderate level of CP during dry period.

2.4.1. Passive transfer of immunity

New-born calf receives antibodies through colostrum from the cow, and it is called passive transfer of immunity, then antibodies in colostrum protect the calf from infections during the first weeks of life (Sjaastad *et al.,* 2016). Successful passive transfer of immunity means that the calf achieves high level of total protein in blood serum. If the calf has less than 50 g total protein per litre blood serum it is defined as failure of passive transfer (FPT) (Beam *et al.*, 2009; Lawrence *et al.*, 2017) and considered as having a higher risk of disease (Weaver *et al.*, 2000). Three main factors cause FPT: a) amount of colostrum fed to the calf, b) quality (concentration of immunoglobulins) of colostrum that is fed to the calf and c) timing for first feeding colostrum after birth (Weaver *et al.*, 2000). Beam *et al*, (2009) found in their study that if the calf had nursed on the cow and had not received a sufficient volume of high-quality colostrum that also could be associated with FPT.

Volume of colostrum fed to the calf, 0.5, 1 or 2 litres, had no effect on absorption period for IgG and IgM but for IgA closure was slightly delayed when 2 litres were fed (Stott *et al.*, 1979b). Morin *et al.* (1997) study prove that amount of IgG fed to calves determines serum IgG. For example, calves that were fed 2 litre colostrum, at birth and at 12 h age, with a low IgG_1 concentration (33 mg/ml) had a lower serum IgG_1 than calves that was fed same time and volume but with colostrum with higher IgG_1 concentration (60 mg/ml). Last group of calves received 4 litres of high IgG_1 concentration colostrum at birth and 2 litres at 12 h age had a significantly higher serum IgG_1 concentration then calves in the two other groups. Higher amount of colostrum did not result in a reduced efficiency of IgG_1 absorption and resulted in no apparent disease or discomfort.

Calves that do not receive enough colostrum or colostrum of bad quality, suffer more often from diarrhea and usually have a slower growth (Sjaastad *et al.*, 2016).

Immunoglobulins have highest possibility for intestinal absorption during first 6 h of age of the calf (Sjaastad *et al*., 2016), after that it gradually decrease until it ceases approximately 24 h age of the calf (Stott *et al*., 1979a). Time of feeding colostrum after birth is important, since it affects the total uptake of Ig (Morin *et al*, 1997). Stott *et al* (1979a; 1979b) studied calves that were fed their first meal at 0, 4, 8, 12, 16, 20 and 24 h age. Calves fed early in life, at 0 h, had an earlier gut closure time and period of absorption time increased in each increasing of age for the calf up to 24 h (Stott *et al*., 1979a). From the first feeding of colostrum the absorption is the highest during the first 4 h compared to the time intervals 4-8 h, 8-12 h and 12-16 h and it is regardless of the age at which the calf gets its first meal (Stott *et al*., 1979b). The absorption is highest during the first 12 h of age after that the absorption rate decreasing in linearly with the increasing age.

The passive transfer of IgG increased when first meal of colostrum was fed first hour of life compared to 6 or 12 h of age (Fisher *et al*., 2018). The calves that were fed within the first h of age also had a significantly higher mean concentration of IgG for the first 27 h of life than those fed at 6 or 12 h of age. They showed that absorption was greatest at birth and then decreased successively.

3. Materials and methods

3.1. Farms

Twenty farms were included in this study. Farms were selected from Växa Sveriges advisors in each region, Halland, Dalarna, Småland, Södermanland and Västmanland, the farm data is presented in (Table 3). The farms were selected according to their feeding strategy for the lactating cows. Primarily, farms in Halland and Dalarna that were contacted, but seven farms declined because of time constraints, two farms in Småland were contacted instead. In principle all farms with TMR were contacted in Dalarna and everyone agreed to participate in the project. In Dalarna there are many smaller farms so otherwise the farms were selected according to a reasonable number of cows (>50 cows). One farm in Dalarna declined due to lack of staff at the time. Nine farms using a TMR, five farms using separate feeding and six farms using partial mixed ration (PMR) were included in the study. Eight farms where located in Halland, two in Småland, eight in Dalarna, one in Västmanland and one in Södermanland. In order to standardize data collection in all farms, a package was sent to each farm. The package contained a scale (hanging scale with a weight range 0 kg to 100 kg;brand Ryom analog), digital thermometer (temperature range 32.0˚C to 43.9˚C, accuracy +/- 0.1˚C and brand Kruuse), measuring tape as an alternative to estimate body weight (measuring range 0 cm to 223 cm; body weight (kg) = 129.9 – 3.251 * chest circumference (cm) + 0.02775 * chest circumference $(cm)^2$ according to Coburn (2000)) and a Brix% refractometer for colostrum (range 0-32 Brix%;Fioniavet). The farmers also received printed data sheets to collect information (Appendix 1) and complementary information (Appendix 2).

Table 3. Characteristic of the farms included in the study

Farm number	Number of cows	Feeding strategy - Dry cows	Organic/Conventional
Farm.1	50-100	TMR	Conventional
Farm.2	50-100	Separate	Conventional
Farm.3	200-300	TMR	Conventional
Farm.4	200-300	TMR	Conventional
Farm.5	200-300	TMR	Organic
Farm.6	>500	TMR	Conventional
Farm.7	100-150	Separate	Conventional
Farm.8	<50	Separate	Conventional
Farm.9	>500	TMR	Conventional
Farm.10	150-200	Separate	Organic
Farm.11	200-300	TMR[1]	Conventional
Farm.12	100-150	TMR[1]	Conventional
Farm.13	300-400	TMR	Conventional
Farm.14	200-300	Separate	Conventional
Farm.15	50-100	Separate	Organic
Farm.16	300-400	Separate	Organic
Farm.17	50-100	Separate	Conventional
Farm.18	200-300	TMR	Organic
Farm.19	50-100	Separate	Organic
Farm.20	100-150	Separate	Conventional

[1]Changed to TMR about 3 weeks before calving. Farm considered as TMR for analysis.

3.1.1. Data collected by farmers

The farmers recorded data during a 2-month period starting at the end of January 2020. Data were collected by the farmers in the data sheets provided and also recorded data into dairy data management and analysis software Kokontrollen (Växa, 2020) or DelPro (DeLaval, 2019). The farmers record colostrum yield at first milking, time of first milking (hours of after calving), colostrum quality by Brix refractometer, calf birth weight by a scale or measuring chest circumference (129.9 – 3.251 * chest circumference (cm) + 0.02775 * chest circumference (cm)^2 according to Coburn (2000)) scoring of calf vitality at birth (1= weak; 2 normal ; 3 alert) and time to first meal colostrum.

3.1.2. Data collected at farm visits

We collect data during one visit to each farm, the visit took place during the period 2020-01-29 to 2020-03-09. We registered data included the occupancy rate at the feed table, management and feeding strategy. Body condition of the dry cows in both early and late dry period was scored. The goal was to score 10 randomly selected cows for body condition but on some farms was not possible since they had fewer cows at the time of visit. To score the body condition a body condition evaluation schedule by Gillund *et al*. (1999) was used (Appendix 3). The scale is between 1 and 5 were 1 indicates under nourished and 5 indicates overweight, the range of the scoring was 0.5. The form that was used during the visit is shown in (Appendix 4).

3.2. Statistical analysis

The data were analysed using the statistical program JMP Pro 15.0.0. For som of the figures Microsoft Excel 16.30 was used. The effect of feeding strategy on colostrum yield and colostrum quality was analysed using standard least square means with parity and body condition score as a co-factor and farm number as random effect, for the colostrum quality also time to first milking after calving was tested as co-factor, and for the colostrum yield also practice of restricted milking was tested as a co-factor.

The effect of feeding strategy on calf birth weight (kg) and calf birth body temperature (°C) was analysed using standard least square means with farm ID as a random effect, for birth weight parity was tested as a co-factor.

The effect of feeding strategy on calf vitality was analysed using the ChiSquare test. Also, the effect sex of the calf and, birth body temperature and birth weight on calf vitality was analysed using the ChiSquare test.

Data are presented in Means ± SEM unless otherwise stated.

4. Results

In total, 578 calvings were recorded (Table 4) but the number of calvings recorded per farm during the two-month period varied greatly between farms (from 5 to 66 calvings). The number of cows scored for body condition is also shown in Table 4.

Table 4. Number of recorded calvings during the study period and number of cows scored for body condition per farm

Farm ID	Number of calvings	Total number of dry cows at visit	Percentage of dry cows assessed for body condition
Farm 1	13	7	100%
Farm 2	7	3	100%
Farm 3	45	26	38%
Farm 4	34	23	43%
Farm 5	35	28	29%
Farm 6	15	81	12%
Farm 7	15	13	46%
Farm 8	15	4	100%
Farm 9	52	70	14%
Farm10	23	18	44%
Farm11	49	28	36%
Farm12	12	14	57%
Farm13	66	19	47%
Farm14	46	17	59%
Farm15	13	5	100%
Farm16	45	22	45%
Farm17	5	6	100%
Farm18	56	33	27
Farm19	14	6	100%
Farm20	18	7	100%

4.1. Dry cow

Fourteen of 20 farms had far-off and close up feeding strategy to their dry cow during the dry period. Six of the 20 farms had the same type of feed and feeding strategy during the whole dry period.

4.1.1. Colostrum yield and quality

The mean colostrum yield was 5 litre and the range of colostrum yield was 0.02 to 25 litres. The variation between the farms is illustrated in figure 5. There was no effect of feeding strategy on colostrum yield, in litre, (TMR = 3.2 ± 0.5 vs separate = 4.3 ± 0.6). However, there were 25 cows that produced less than 1 litre of colostrum (TMR 21/294 = 7.1% and separate 4/160 = 2.5%), see figure 6. From these, 15 were in parity 1 (TMR n=14 and separate n=1).

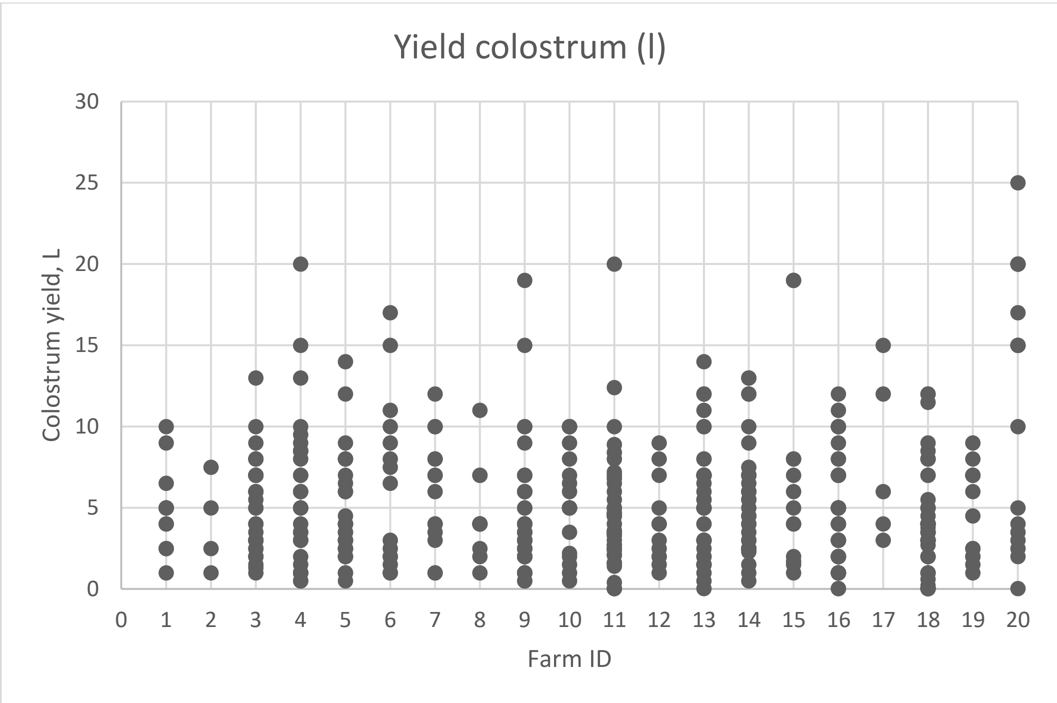


Figure 5. Colostrum yield, difference between the farms, were each point represent one cow.

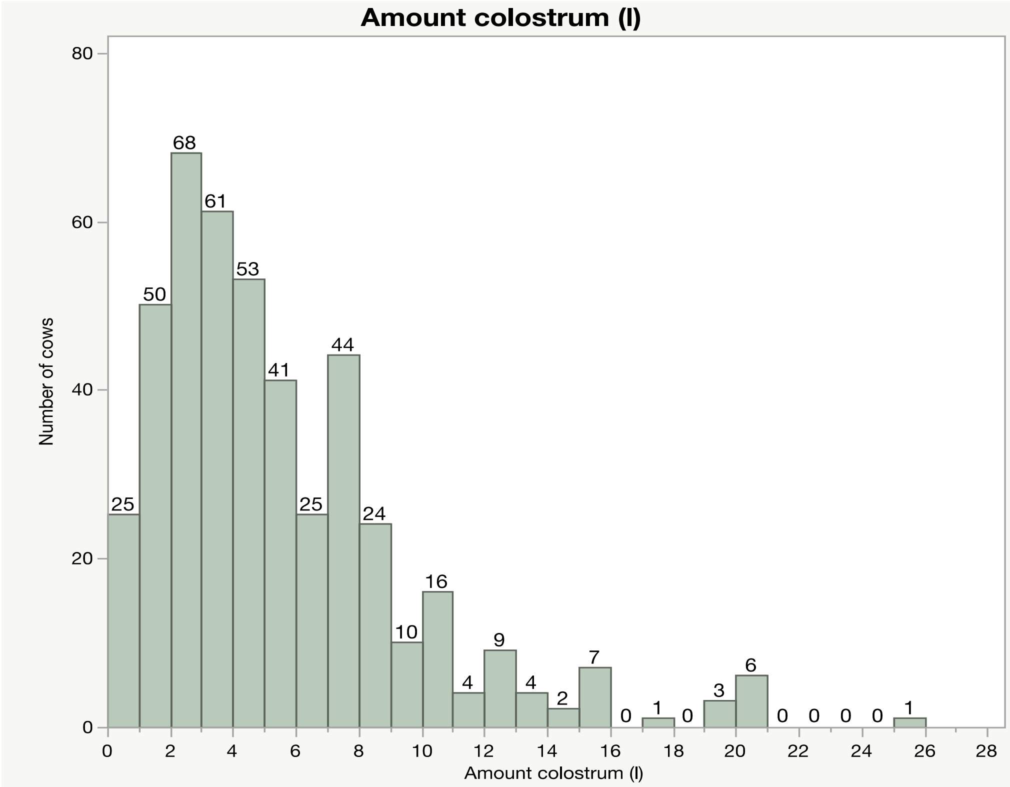


Figure 6. Colostrum yield.

There was a significant effect of parity on colostrum production (p<0.0001) with primiparous animal producing significantly less colostrum than cows in lactation number 2-4 (Figure 7). Cows in parity 5-8 (n=51) were excluded because of too few animals. There was no effect of body condition score on colostrum yield. Of the 20 farms 12 of them milked out all colostrum at the first milking, the rest of the farms had incomplete colostrum milking in some or all of the cows due to concerns about increasing the risk of milk fever (Table 5). However, there was no effect of farmer milked out completely or not on the colostrum yield.

Table 5. Management first milking after calving, number of farms

Feeding strategy	Milk out completely	Does not completely milk out all colostrum	Leaves milk on older/ill cows
TMR	8	-	2
Separate	3	4	2

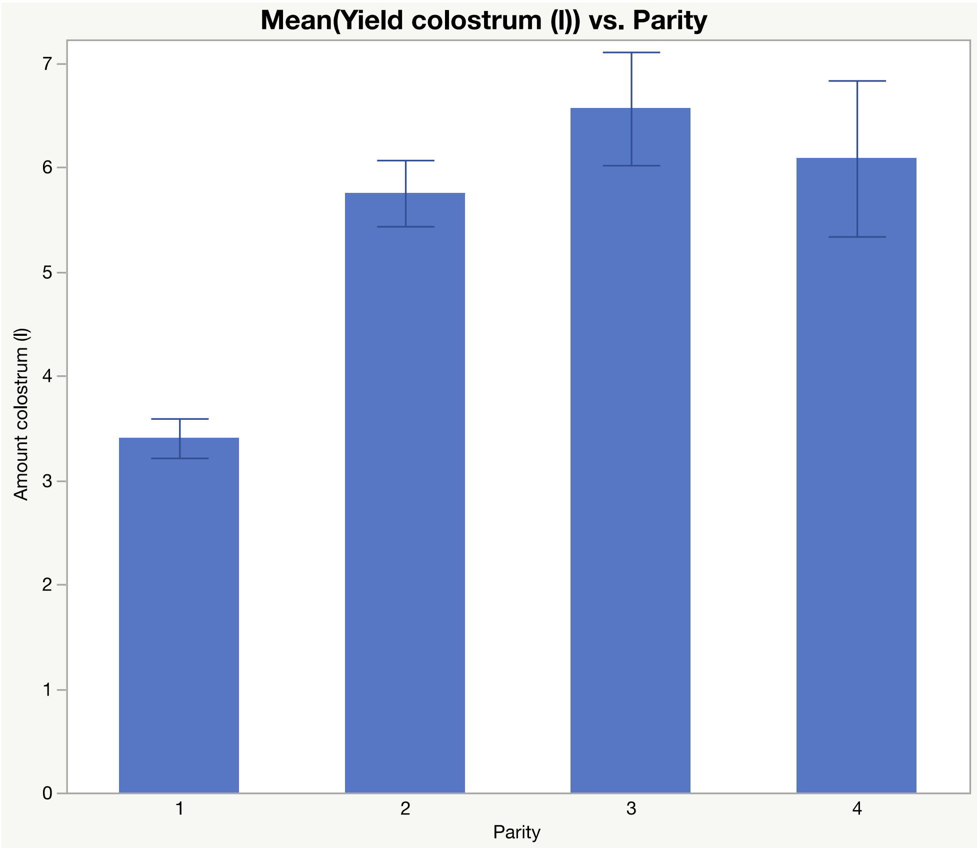


Figure 7. Effect of parity on yield colostrum.

The mean colostrum quality was 24% Brix and mean time in h to first milking after calving was 3.7 h. The range of colostrum quality was 11 to 41 %. There were 120 cows that produced colostrum with less than 22% Brix (TMR 27/75 cows (36%) and separate 16/45 cows (36%) producing colostrum with < 22% Brix). From these, one third were in parity 1 (43 animals). Of the 117 cows that were milked within 2 h there was only 24 of them that had a colostrum quality below 22% Brix. Mean Brix value for the farms range from 20.2 to 29.2 %. The variation between the farms is shown in figure 8. There was a tendency for TMR cows produce colostrum with higher quality than cows with separate feeding during the dry period (TMR = 22.1 ± 0.6 vs separate = 20.8 ± 0.6 Brix%, $p<0.09$).

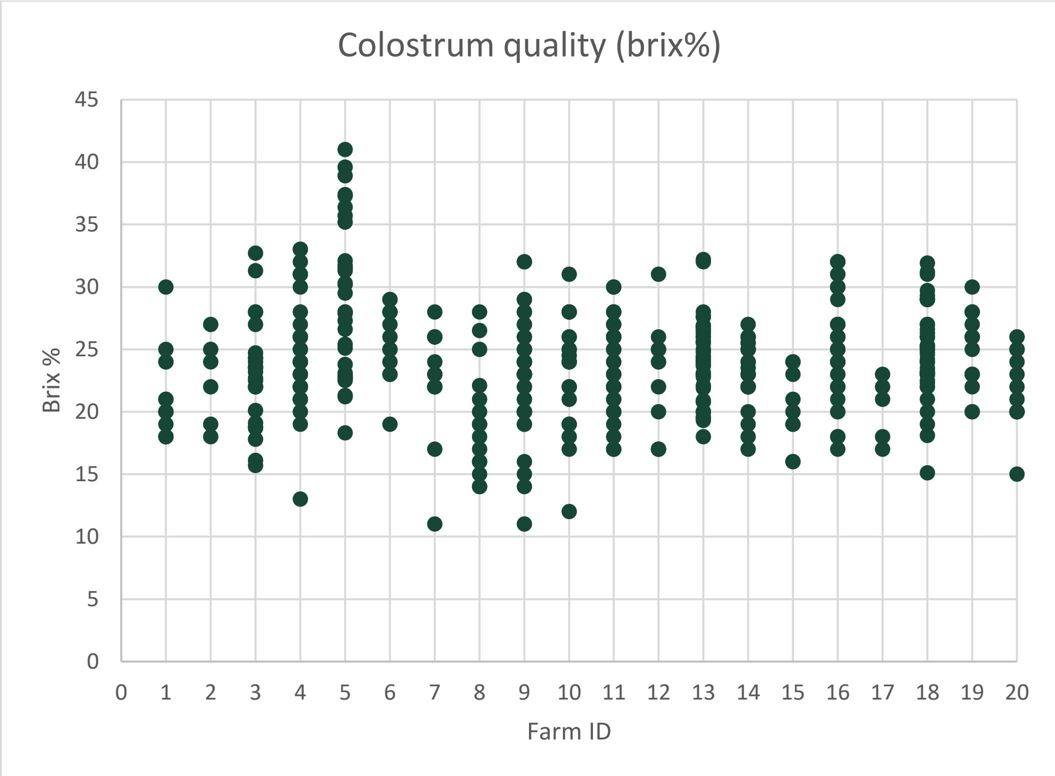


Figure 8. Colostrum quality in Brix %, difference between the farms. Each dot represents one cow.

There was no effect of parity on colostrum quality. There was a significant effect of time (h) to first milking after calving ($p<0.0001$), with decreased colostrum quality as time after calving to first milking increased (Figure 9). TMR farms were a little bit better to milk the cow early after calving compared to the farms with separate feeding (milking 0-6 h after calving TMR = 86% vs separate = 82%). There was no effect of body condition score on colostrum quality. First milking varied widely in time after calving from 0 to 30 h, see figure 10.

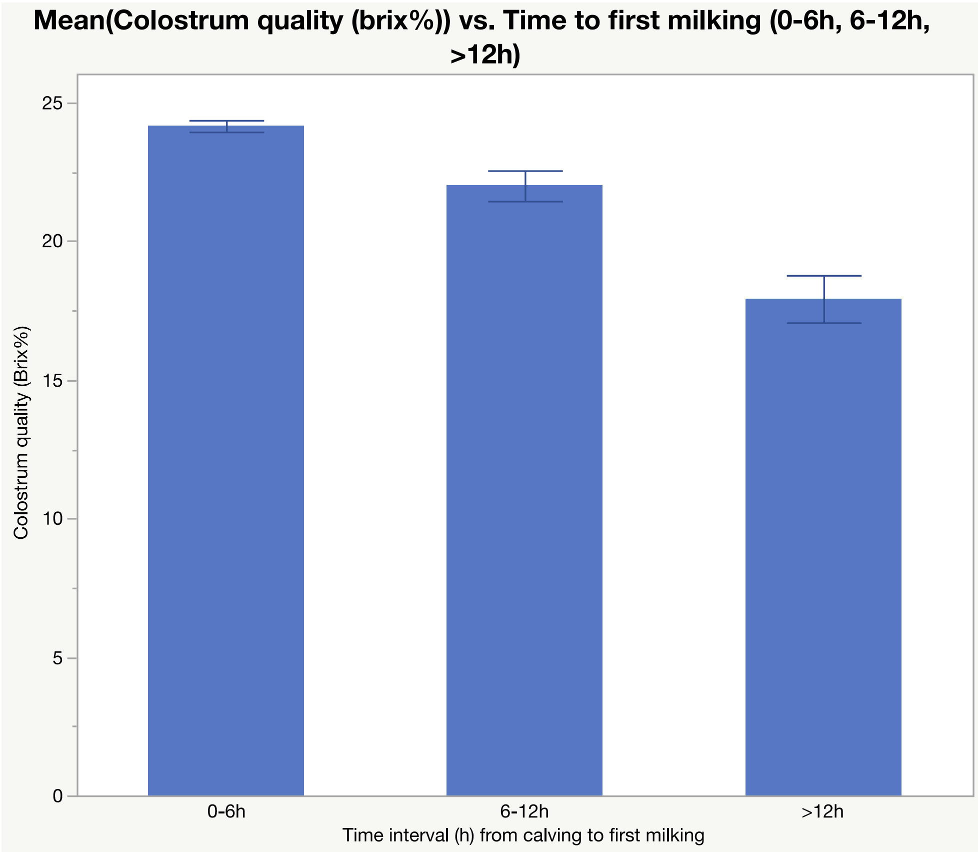


Figure 9. Effect of time from calving to first milking on colostrum quality (Brix%).

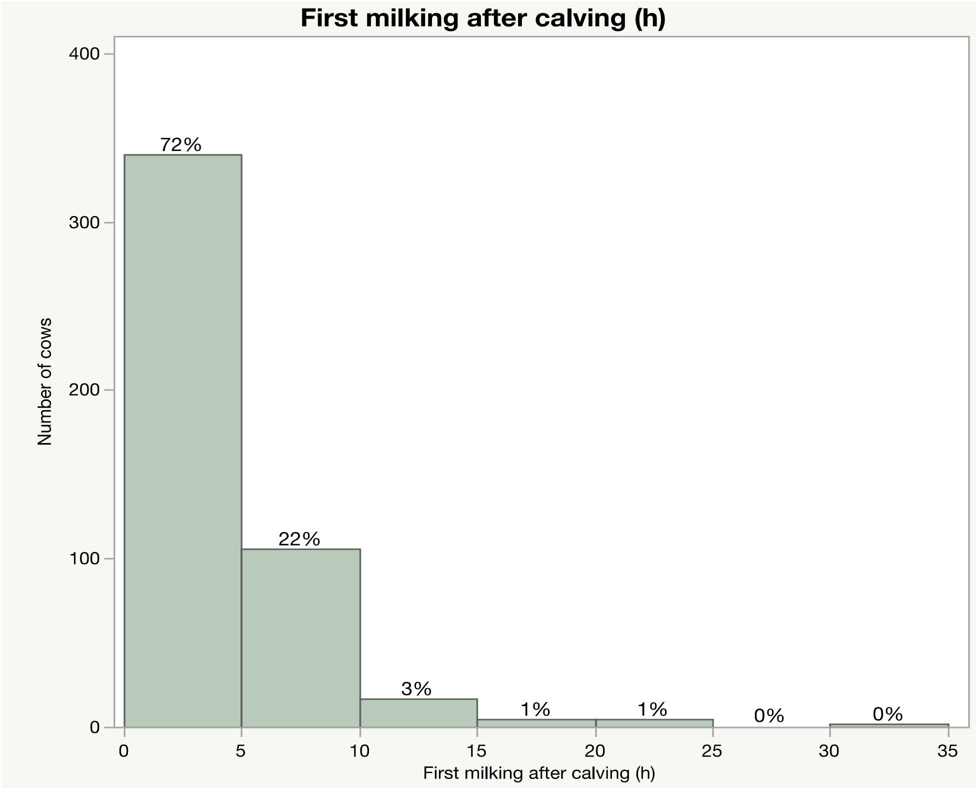


Figure 10. Time interval to first milking after calving, percent of total number of dry cows.

4.1.2. Calf birth weight, body temperature and vitality

Birth weight was measured on 430 calves and ranged from 23 to 69 kg. There was a weak trend ($p<0.0847$) of feeding strategy on calf birth weight where calves from cows that had separate feeding during the dry period had higher birth weight than calves from cows fed TMR (44.2 kg ± 0.9 and 42.0 kg ± 0.8, respectively). However, had parity of the cow an effect on birth weight ($p<0.0001$) were calves born from older cows had a higher birth weight, see figure 11.

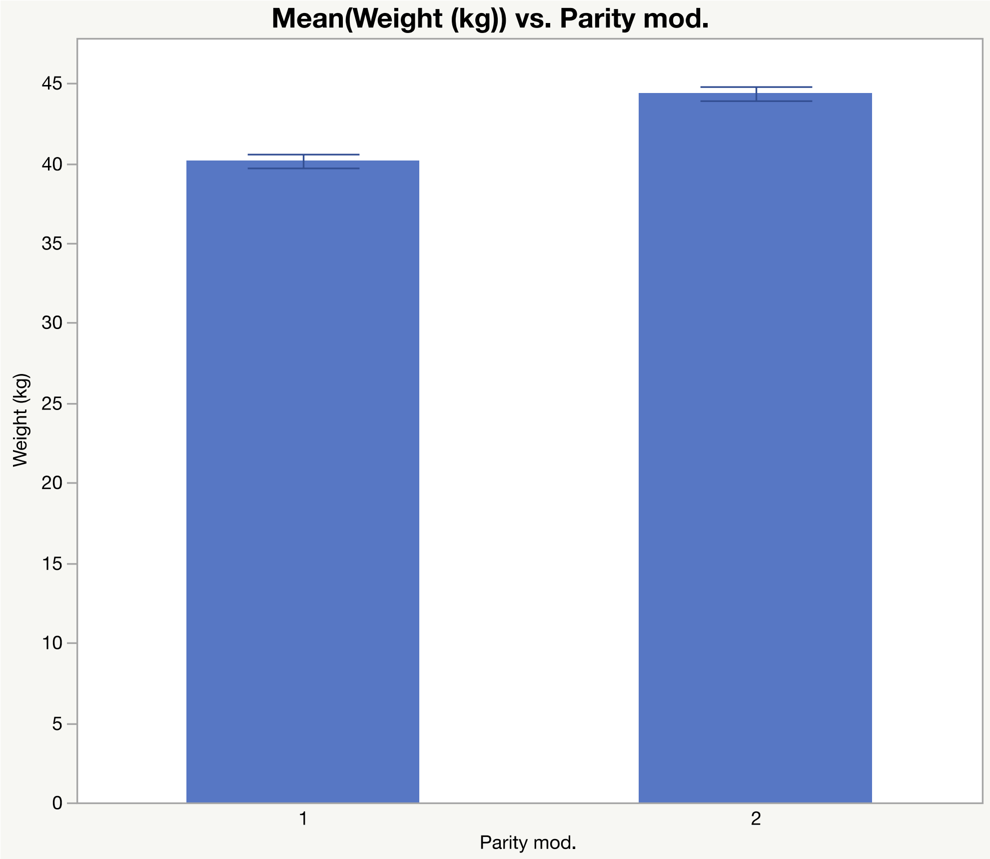


Figure 11. Parity effect on calf birth weight. 1 = primiparous, 2 = multiparous.

Body temperature was measured on 470 calves and ranged from 35.9 to 40.5°C. There was no effect of feeding strategy on calf birth body temperature (TMR = 38.6°C ± 0.09 vs separate = 38.6 ± 0.09). One calf was excluded because it had been vigorous cooled down before the temperature was measured, that calf has a body temperature of 32.5 ° C at the time of measurement.

The feeding strategy had effect on vitality of the calf ($p<0.001$), were calves from cows fed separate feeding had higher vitality score, see (Figure 12). Calves scored alert vitality tended ($p<0.07$) to have higher birth weight (44.4 kg ± 0.6) than those scored normal (42.3 kg ± 0.5) vitality and weak (43.5 kg ± 1.1). Neither birth temperature nor the sex of the calf had no effect on calf vitality.

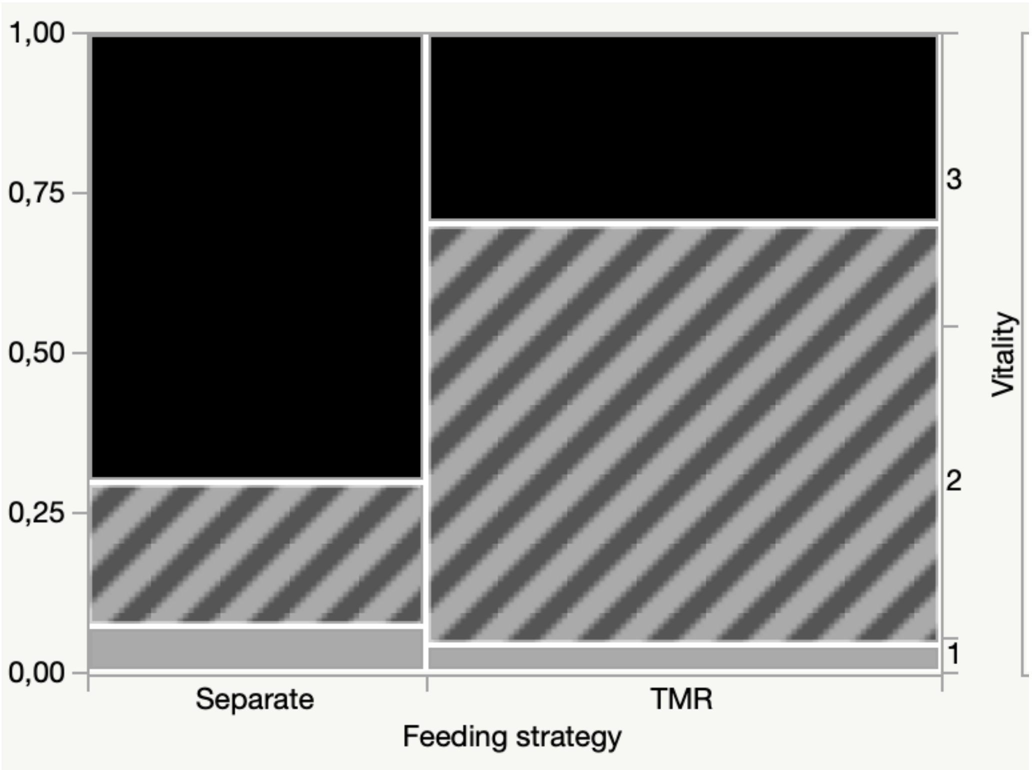


Figure 12. Calf vitality. 1 = weak (gray), 2 = normal (striped), and 3 = alert (black). On y axis proportion of animals.

4.2. Calves and colostrum management

The majority of the farms (19/20 farms) gave their calves the first meal of colostrum in a bottle with nipple, one farm let the calves suckle the cow to obtain colostrum. Similarly, the majority of farms (18/20 farms) gave transition colostrum/milk to the calves. Twelve farms said that they had a strategy of using high quality colostrum the first meal to calves. The lowest Brix value on colostrum that was fed to the calves varied between farms (see Table 6). Eight of 20 farms did not measure or had not a routine for measuring the Brix value on the colostrum before this project.

Table 6. Lowest Brix value on the colostrum that was feed to the calves

Lowest Brix value	Number of farms
20%	3
21%	2
22%	5
23%	2

The results from this study of management factors about colostrum to the calf are shown in Table 7. For the time to first meal there was a large variation between individual calves (0 to 30 h).

Table 7. Mean amount colostrum, average time to first mean after calving and mean colostrum quality to the calf

Feeding strategy	TMR	Separate
Amount colostrum Mean ± Std Err	2.7±0.05	2.7±0.08
Time to first meal (h) Mean ± Std Err	2.7±0.16	2.6±0.15
Colostrum quality to calf Mean ± Std Err	24.4±0.25	23.1±0.31

5. Discussion

This study investigated the effects of dry cow feeding strategies (TMR and separate feeding) on colostrum yield, colostrum quality, and calf health. The results suggest that the farms with separate feeding scored their calves as having higher vitality and tended to have calves with higher birth weight, while TMR farms tended to get higher colostrum quality. Feeding strategy had no effect on colostrum yield or birth body temperature of the calf. However, due to the fact that almost all the data in this study were collected by the farmers (at least 20 different people) that could have interpreted the instructions differently, the findings reported in this study should be interpreted with caution. Body condition and vitality were assessed subjectively as a score by different people and this could be another source of error. Furthermore, differences in terms of farm size, breeds used, milking systems and organic vs conventional all could also have had an impact on the results.

5.1. Colostrum yield and quality

5.1.1. Effect of feeding strategy

The result from this study showed that the feeding strategy (TMR or separate) had no effect on colostrum yield, but there was a trend on colostrum quality were TMR cows produce colostrum with a better quality than the cow with separate feeding during the dry period, although the difference was small. However almost half of all samples were below the recommended level of 22 % Brix in both strategies. This result is different from previous studies that find that TMR cows had a higher colostrum yield than dry cows that received grass silage but for the colostrum quality there was no difference (Dunn *et al.*, 2017).

Although TMR was part of both this study and in Dunn et al. (2017) study, it can be problematic to compare them directly as there may be differences in feed intake and diet composition, for example energy level, CP, NDF etc. Even for the farms that participate in our study there were large differences in feed composition both among TMR and separate feeding farms. Feed intake and diet composition on the 20 farms included on this thesis has been reported in another MSc thesis by Lindqvist (*in press*).

Another factor that could been seen as a source of error is that some of the farms milked out their cows of all colostrum at the first milking and some of them did not, which could mean that in some farms the yield of colostrum could be higher. There is nothing to support the strategy to not milked out all colostrum, the recommendation is total milking. However, this factor did not have any significant effect on the colostrum yield. Maybe one partial explanation of why TMR cows had a tendency to produce colostrum with better quality is because of the TMR farms were a little bit better to milk the cow early after calving compared to the farms with separate feeding.

5.1.2. Body condition

The body condition score at late pregnancy, less than 21 days to calving, had no effect on colostrum yield or colostrum quality. Shearer *et al.* (1992) found that cows in body condition score 3 (in a 1 to 5-point scale) were less likely to produce colostrum with a high Ig concentration than the cows in body condition score 2.5, which does not agree with the results from this study. However, there were a few observations on body condition score near calving which could have an effect on the result from this study. Shearer *et al.* (1992) also found that the cows that gained in body condition had a significant higher colostrum quality (Ig concentration) compared to dry cows that lost body condition. In the present study, body condition score was measured only once so we cannot confirm if change in body condition had effect on colostrum quality observed.

5.1.3. Parity

The result from this study shows that multiparous cows produced higher colostrum yield than primiparous seems to agree with the literature. McGee *et al.* (2006) found that multiparous cows with an average lactation number 6 had significant higher colostrum yield than primiparous that ate the same type of grass silage before calving. The same type of trend was found in this study that the yield is increasing with increasing age but in this study the cows in this study received different diets due to the different farms. One other source of error could be that it was uneven number of cows for each parity. The primiparous cows was in majority in this study and the number of cows decreased for each increasing parity.

The result from this study did not support the literature about increasing age increase the quality of colostrum. Shearer *et al.* (1992) could show a top at fourth lactation when the quality not increasing anymore which not seems to agree with the result from this study. Even here one error source that could be the case for this study is that it was uneven number of cows for each parity. It was most primiparous in this study and the number of cows decreased for each increase in parity. Godden (2008) argues, that it could be the case that older cows have greater quality on the colostrum is probably due to older animals having and greater exposure to local pathogens. That the number of primiparous in a herd is high could be a reason for that total colostrum quality on a farm is low, that seems also be the case for the farm in this study then the level of primiparous is high.

5.1.4. Delayed colostrum milking

Previous studies have shown that increasing time to first milking after calving decrease the quality of colostrum, the result from this study support that. Moore *et al.* (2005) suggest that one way to increase the colostrum quality and decrease the frequency of FPT is to have a better system for cows that recently have calved, so that they are assured that they will be milked as quickly as possible, preferably within 2 h, and that they do not have to wait to the other cows are milked. Out of 469 observations in this study only 25% were of the cows milked within 2 h and only 5% of the cows had lower Brix value than 22% in the first meal. That indicate that could be a good idea to have a system that the cows get milked within 2 h. One of the cows was milked for the first time after 30 h, it can be seen as a very long time, and maybe the calf has suckled the cow before the milking and the farmer have forgotten to note that. This could be seen as a source of error.

5.2. Calf

5.2.1. Birth weight

Normal birth weight of a calf is considered to be between 40-50 kilos (Kalvportalen, 2019c). The results from this study show that there was a trend of feeding strategy (TMR and separate) on birth weight, were calves from cows that ate separate feeding during the dry period had a higher birth weight. The literature about dry cow feeding and how it affects the birth weight of the calf has also shown that the feeding during the dry period has no effect on birth weight of the calf. Instead Nowak *et al*. (2012a) found that energy content during the dry period had an effect of the daily body gain after birth for the calf. In this study, daily body gain was not measured, which also meant that this comparison between feeding strategy and daily body gain could not be carried out. Since previous studies have shown that the feed has no effect on calf birth weight, it is close to thinking that the result of this study, where there was a trend, is just a coincidence.

All farmers were prompted to measure their calves even if they also weighed the calves, this to make it easier to compare. When the data was sent back it turned out that all farms had not done so, therefore the calves measured in cm had to be translated in kg using the equation of Coburn (2000). One farm was also excluded because of insufficient data on calf weight. All this means that the result can be considered uncertain and that these factors are a source of error.

5.2.2. Birth body temperature

The results from this study showed that there was no effect of the feeding strategy (TMR and separate) on the birth body temperature of the calf. This result supports the literature, Carstens *et al.* (1987) found that different levels of protein to the dry cow during the dry period did not have any effect on the birth weight of the calf.

5.2.3. Vitality

The finding that calf vitality was higher in separate feeding cows should be interpreted with caution since this factor was very subjective and easy for farmers to score differently, even if they received instructions on how they should score it, see (Appendix 2). Furthermore, even though the proportion of high vitality calves was higher in separate feeding group, the total proportion of normal calves was higher in TMR calves and the proportion of low vitality calves in both treatments was similar. Therefore, it is not possible to establish if one feeding strategy leads to calves that are livelier. As the assessment was made it does not indicate that the normal calf is less healthy than the alert calf. It is also hard to conclude that the weight has a tendency for the vitality when the weights do not follow a pattern along with the vitality. This lack of agreement could be partially explained by the problems mentioned above regarding reliability of the measurement of calf birth weight. Heavier calves had been scored with high vitality (alert) in higher degree, maybe that would be the case, but it can also be that the farmers tend to score a higher vitality for the calf that was bigger. In general, all farms had newborn calves with normal and alert vitality

5.3. Calves and colostrum management

There were no differences in management factors (mean amount colostrum to the calves, average time to first meal after calving and mean colostrum quality to the calf) between the feeding strategies. But there were more observations within the TMR farms that have to be considered as a source of error. However, it was expected that it was no difference in management factors between the feeding strategies since it should not affect when the farmer chooses to fed, or what quality of colostrum the farmers choose to feed with.

The mean colostrum amount that was fed to the calf was 2.7 l in this study. A high colostrum amount fed to the calf can be one way to insure the passive transfer.

Morin *et al.* (1997) found that a higher volume of colostrum, 4 litres compared to 2 litres, did not result in reduced efficiency of IgG1 absorption, nor in any disease or discomfort. That can be an argument to feed the calf a higher amount of colostrum. Although it is considered positively the more colostrum the calf can ingest early in life the more nutrients it receives and hence grow.

In this study calves were fed 2.6 to 2.7 h after birth on average. Stott *et al.* (1979b) have shown that the time to first feeding has an effect on the total uptake of Ig. The absorption is highest within the first 12 h after birth and after that the absorption decrease with increasing age. But Fisher *et al*. (2018) have shown that the immunoglobulin absorption rate decreases very fast with the highest absorption rate occurring when feeding 45 min after birth. This indicates that it is important to feed the calf high quality colostrum at first meal and that the first meal is feed early in life. The calves in this study received on average the first meal of colostrum within 3 h after birth, which is good but could be further reduced to increase the chances of achieving a good transfer of passive immunity.

In this study, the colostrum that was fed to the calf was on average 23.9% Brix which is in line with the recommended 22 Brix% value (AHDB Dairy, 2015). However, if there is a shortage of colostrum it is still possible to feed colostrum with slightly lower quality (18-22 Brix%) if the calves are feed a bigger meal (Kalvportalen, 2019b).

All these three factors, amount, timing and quality are important together. To ensure a good passive transfer all of these factors need to take into account as one factor is not more important than the other.

In the present study, almost half of the farms did not measure or did not have a good routine for measuring the quality of colostrum before this project. Therefore, in some farms this can be regarded as areas of improvement to ensure that the calf receives adequate transfer of passive immunity.

6. Conclusion

The feeding strategy (TMR or separate) to dry cows on 20 Swedish farms did not have any effect on the colostrum yield. However, TMR fed dry cows tended to produce colostrum with a slightly higher quality than separate fed, although both strategies had on average good quality (more than 22% Brix). Feeding strategy did not affect calf birth weight or birth body temperature. However, calves from separate feeding farms were scored as having higher calf vitality and tended to have higher birth weight than calves from TMR farms. Time to first milking had an effect on the colostrum quality. Of the cows that were milked before 6 h after calving 86% had good quality colostrum (above 22% Brix). Parity had effect on colostrum yield with primiparous cows yielding about half of the amount of colostrum than multiparous cows (3 vs 6 litres). In addition, about 13% of the cows (n=60) yielded less than 1 litre colostrum in the first milking, which is alarming. Since this was a field study, it was not possible to control important factors such as feed quality, feed intake and calving management practices, all of which could have affected these results. Therefore, further controlled studies are needed to confirm these findings.

References

Agriculture and Horticulture Development Board (2015). *Using a colostrometer*. [Broschyr]. Kenilworth: AHDB Dairy. Available: https://www.farmantibiotics.org/wp-content/uploads/2018/01/j2247_dairy_calf_amends_sec4_testing_colostrum_aw2.pdf [2020-04-23].

Beam, A. L., Lombard, J. E., Kopral, C. A., Garber, L. P., Winter, A. L., Hicks, J. A., Schlater, J. L. (2009). Prevalence of failure of passive transfer of immunity in newborn heifer calves and associated management practices on US dairy operations. *Journal of Dairy Science*. vol. 92. pp. 3973-3980.

Buczinski, S. & Vandeweerd, J. M. (2016). Diagnostic accuracy of refractometry for assessing bovine colostrum quality: A systematic review and meta analysis. *Journal of Dairy Science*. vol. 99. pp. 7381–7394.

Carstens, G. E., Johnson, D. E., Holland, M. D., Odde, K. G. (1987). Effects of prepartum protein nutrition and birth weight on basal metabolism in bovine neonates. Journal of Animal Science. vol. 64. pp. 745-751.

Coburn (2000). Holstein Dairy Tape. Developed by Dairy & Animal Science Dept. of the Pennsylvania State University.

Conneely, M., Berry, D. P., Sayers, R., Murphy, J. P., Lorenz, I., Doherty, M. L., Kennedy, E. (2013). Factors associated with the concentration of immunoglobulin G in the colostrum of dairy cows. *The Animal Consortium*. vol. 7. pp. 1824-1832.

Dann, H. M., Litherland, N. B., Underwood, J. P., Bionaz, M., Angelo, A. D.,McFadden, J. W., Drackley, J. K., Diets during Far-Off and Close-Up dry periods affect periparturient metabolism and lactation in multiparous cows. *Journal of Dairy Science*. vol. 89. pp. 3563–3577.

Denholm, K. S., McDougall, S., Chambers, G., Clough, W. (2018). Factors associated with colostrum quality in individual cows from dairy herds in the Waikato region of New Zealand. *New Zealand Veterinary Journal* vol. 66(3). pp. 115–120.

De Haan, T. (2018). Hur råmjölkskvalitet och upptag av immunoglobulin påverkar kalvhälsa. ISSN1652-8697. Swedish University of Agricultural Science. Instutionen för kliniska vetenskaper. https://stud.epsilon.slu.se/13666/7/de_haan_t_180912.pdf

DeLaval (2019). *DelPro applikationer*. Avalible:

https://www.delaval.com/sv/vara-losningar/farm-management/delaval-delpro-applications/ [2020-03-27].

Dunn, A., Ashfiled, A., Earley, B., Welsh, M., Gordon, A., McGee, M., Morrison, S. J. (2017). Effect of concentrate supplementation during the dry period on colostrum quality and effect of colostrum feeding regimen on passive transfer of immunity, calf health, and performance. *Journal of Dairy Science.* vol. 100. pp. 357-370.

Farrell, H. M., Jimenez-Flores, Jr., R., Bleck, G. T., Brown, E. M., Butler, J. E., Creamer, L. K., Hicks, C. L., Hollar, C. M., Ng-Kwai-Hang, K. F., Swaisgood, H. E. (2004). Nomenclature of the Proteins of Cows' Milk - Sixth Revision. *Journal of Dairy Science*. vol. 87. pp. 1641-1674.

Fisher, A. J., Song, Y., He, Z., Haines, D. M., Guan, L. L., Steele, M. A. (2018). Effect of delaying colostrum feeding on passive transfer and intestinal bacterial colonization in neonatal male Holstein calves. *Journal of Dairy Science.* vol. 101. pp. 3099-3109.

Godden, S. (2008). Colostrum Management for Dairy Calves. *Veterinary Clinic Food Animal Practice* vol. 24 pp. 19–39.

Goff, J. P., Stabel, J. R. (1990). Decreased Plasma Retinol, a-Tocopherol, and Zinc Concentration During the Periparturient Period: Effect of Milk Fever. *Journal of dairy Science.* vol. 73. pp. 3195-3199.

Hostetler, D., Douglas, V. L., Tyler, J., Holle, J., Steveens, B. (2003). Immunoglobulin G concentrations in temporal fractions of first milking colostrum in dairy cows. *Journal of applied research in veterinary medicine.* vol 1. pp. 168-171.

Kalvportalen (2019a). *Nedkylning.* Available: http://www.kalvportalen.se/kalvning/den-nyfoedda-kalven/nedkylning/

Kalvportalen (2019b). *Testa råmjölken.* Available: http://www.kalvportalen.se/raamjoelk/testa-utvaerdera/testa-raamjoelken/

Kalvportalen (2019c). *Tillväxt och vägning.* Available: http://www.kalvportalen.se/skoetsel/tillvaext-hullbedoemning/tillvaext-och-vaegning/

Kalvportalen (2019d). *Upptag av antikroppar.* Available: http://www.kalvportalen.se/raamjoelk/om-raamjoelk/upptag-av-antikroppar/

Kume, S. I. Tanabe, S. (1993). Effect of Parity on Colostral Mineral Concentrations of Holstein Cows and Value of Colostrum as a Mineral Source for Newborn Calves. *Journal of Dairy Science.* vol. 76. pp. 1654-1660.

Lawrence, K., Broerse, N., Hine, L., Yapura, J., Tulley, W. J. (2017). Prevalence of failure of passive transfer of maternal antibodies in dairy calves in the Manawatu region of New Zealand. *New Zealand Veterinary Journal.* vol. 65. pp. 1-5.

Lindmark-Månsson, H., Fondén, R. & Pettersson, H-E. (2003). Composition of Swedish dairy milk. *International Dairy Journal.* vol. 13. pp. 409-425.

Lopera, C., Zimpe, R., Vieiera-Neto, A., Lopes, F. R., Ortiz, W., Poindexter, M., Faria, B. N., Gambarini, M. L., Block, E. Nelson, C. D., Santos, J. E. P. (2018). Effects of level of dietary cation-anion difference and duration of prepartum feeding on performance and metabolism of dairy cows. *Journal of Dairy Science.* vol. 101. pp. 7907-7929.

Mann, S., Leal Yepes, F. A., Overton, T. R., Lock, A. L., Lamb, S. V., Wakshlag, J. J., Nydam, D. V. (2016). Effect of dry period dietary energy level in dairy cattle on volume, concentration of immunoglobulin G, insulin, and fatty acid composition of colostrum. *Journal of Dairy Science.* vol. 99. pp. 1515-1526.

McGee, M., Drennan, M. J., Caffrey, P. J. (2006). Effect of age and nutrient restriction pre partum on beef suckler cow serum immunoglobulin concentrations, colostrum yield, composition and immunoglobulin concentration and immune status of their progeny. *Irish Journal of Agricultural and Food Research.* vol. 45. pp. 157-171.

Moore, M., Tyler, J. W., Chigerwe, M., Dawes, M. E., Middleton, J. R. (2005). Effect of delayed colostrum collection on colostral IgG concentration in dairy cows. *Journal of the American Veterinary Medical Association.* vol. 226. pp. 1375-1377.

Morin, D. E., McCOY, G. C., Hurley, W. L. (1997). Effects of Quality, Quantity, and Timing of Colostrum Feeding and Addition of a Dried Colostrum Supplement on Immunoglobulin G1 Absorption in Holstein Bull Calves. *Journal of Dairy Science.* vol. 80. pp. 747-753.

Nielsen, N., Volden, H. (2011). Animal requirements and recommendations In Norfor – the Nordic feed evaluation system. EAAP publication no. 130 (ed. H Volden), pp. 105-109. Wageningen Academic Publishers, the Netherlands.

Nowak, W., Mikula, R., Zachwieja, A., Paczyńska, K., Pecka, E., Drazga, K., Slósarz, (2012a). The impact of cow nutrition in the dry period on colostrum quality and immune status of calves. *Journal of Veterinary Sciences.* vol. 15. pp. 77-82.

Nowak, W., Mikula, R., Kasaprowicz-Potocka, M., Ignatowicz, M., Zachieja, A., Paczyńska, K., Pecka, E. (2012b). Effect of cow nutrition in the far-off period on colostrum quality and immune response of calves. *Bulletin of the Veterinary Institute in Pulawy.* vol. 56. pp. 242-246.

Quigley, J. D., Hill, G. M., Chapman, C., Erickson, P., Polo, J. (2013). Evaluation of the Brix refractometer to estimate immunoglobulin G concentration in bovine colostrum. *Journal of Dairy Science*. vol 96. pp. 1148-1155.

Rowntree, J.E., Hill, G.M., Hawkins, D.R., Link, J.E., Rincker, M.J., Bednar, G.W., Kreft, R.A. Jr (2004). Effect of selenium on selenoprotein activity and thyroid hormone metabolism in beef and dairy cows and calves. *Journal of Animal Science.* vol. 82. pp. 2995-3005.

Sheare, J., Mohammedb, H. O., Brennemanaand, J. S., Trana, Q. (1992). Factors associated with concentration of immunoglobulins in colostrum at the first milking post-calving. *Preventive Veterinary Medicine.* vol 14. pp. 143-154.

Sjaastad, Ø. V., Sand, O., Hove, K. (2016). Physiology of domestic animals.

Stockdale, C. R., Smith, C. J. (2004). Effect of energy and protein nutrition in late gestation on immunoglobuline G in the colostrum of dairy cows with varying body condition score. *Animal Production in Australia.* vol. 25. pp. 176-179.

Stott, G. H., Marx, D. B., Menefee, B. E., Nightengale, G. T. (1979a). Colostral Immunoglobulin Transfer in Calves I. Period of Absorption. Period of Absorption. *Journal of Dairy Science.* vol. 62. pp. 1632-1638.

Stott, G. H., Marx, D. B., Menefee, B. E., Nightengale, G. T. (1979b). Colostral Immunoglobulin Transfer in Calves II. The Rate of Absorption. Period of Absorption. *Journal of Dairy Science.* vol. 62. pp. 1766-1773.

Suttle, N. F. (2010). Mineral Nutrition of Livestock. 4th Edition. Wallingford: CAB International.

Toghyani, E. & Moharrery, A. (2015). Effect of various levels of dietary protein in transition period on colostrum quality and serum immunoglobulin concentration in Holstein cows and their newborn calves.

Växa Sverige (2020). *Kokontrollen*. Available: https://www.vxa.se/kokontrollen

Weaver, D. M., Tyler, J. W., VanMetre, D. C., Hostetler, D. E., Barrington, G. M. (2000). Passive Transfer of Colostral Immunoglobulins in Calves. *Journal Veterinary Internal Medicine.* vol. 14. pp. 569-577.

Populärvetenskaplig sammanfattning

Råmjölk är viktigt för alla däggdjur då det förser den nyfödda med livsviktiga näringsämnen så som antikroppar, vitaminer och fett. För en del däggdjur förs antikroppar – IgG över från mamman till fostret via moderkakan men för kalvar sker denna överföring uteslutande via råmjölken. Därför ställer det höga krav på att det produceras tillräcklig mängd råmjölk och att den är av bra kvalitet.

Att veta vilka faktorer som påverkar råmjölksmängden och råmjölkskvaliteten är viktigt för att kunna säkerställa en bra råmjölksproduktion. Hur vida fodret under sinperioden har en påverkan på detta område är forskningen inte enad om i dagsläget. Syftet med detta examensarbete var att undersöka vad två olika fodrerstrategier a) fullfoder, eller b) separatutfodring, under sinperioden har för påverkan på råmjölksproduktionen sam vad det har för påverkan på kalvhälsan.

Resultaten från den här studien grundade sig på datainsamlingar som gjorts ute på 20 gårdar, dessa gårdar var utvalda utefter sin foderstrategi, fullfoder eller separat utfodring. Utifrån endagars foderstatsberäkning som genomfördes på varje gård gick det att få fram foderstatens totala innehåll av olika komponenter.

Resultatet från denna studie visar att foderstrategierna TMR och separat utfodring hade råmjölkskvaliteten en tendens till att påverka råmjölkskvaliteten där korna som hade fullfoder som foderstrategi under sinperioden hade en något bättre råmjölkskvalitet. Däremot var det ingen skillnad mellan foderstrategiernas påverkan på råmjölksmängden. Hullpoängen hade inte heller någon effekt på dessa parametrar. Den faktorn som hade effekt på råmjölksmängden var kalvningsnummer, äldre kor producerade en större mängd råmjölk än första kalvare.

För råmjölkskvaliteten hade tiden till första mjölkning efter kalvning också en effekt på råmjölkskvaliteten, där ökad tid ledde till försämrad kvalitet på råmjölken. Dessa resultat stämmer bra in på den forskning som tidigare gjorts inom detta område.

Kalvens hälsa vad det gäller födelsevikt och födelsetemperatur hade foderstrategierna inte någon påverkan på, men det fanns en tendens till att separat utfodring leder till högre födelsevikt hos kalvarna. Däremot hade foderstrategierna en effekt på kalvens vitalitet vid födsel. Där separat utfodrade kor tenderade att få kalvar med högre vitalitet. Mer forskning på detta område behövs för att säkerställa foderstrategierna inverkan på dessa områden, även om det i denna studie fanns antydningar till att fodret under sinperioden har en påverkan på råmjölksproduktion och kalvhälsan.

Appendix 1 Tables

Calf-ID				
ID-mum				
Birth date + approximately time				
Birth weight/breast size[1]				
Calf temperature at birth[2]				
Yield of colostrum at first meal				
Hours after calving with first meal of colostrum				
Colostrum from another cow than the mother - (ID)				
Vitality at birth (weak/normal/alert)[3]				
How long does the calf stay with the cow (hours)				
Diesease[4]				
Treatment[5]				
Does the calf receive supplementary meal milk when it goes with the cow - if so how many and the quantity[5]				

Cow-ID				
Date of calving				
Yield of colostrum at first milking				
How many hours after calving the cow is milked				
Quality of colostrum - Brix%[7]				
Treatment[8]				
Supplement during the dry period[9]				
Length of dry period				
Calving difficulty[10]				

Other comments or additions:

____

____

____

Appendix 2 Complementary information

Complementary information to the tables

<u>Table - calf</u>

1. Breast size in cm. If you use a scale also enter the birth weight in kg.

2. Calf temperature at birth - so fast as possible after birth. Always use lube or ointment on the thermometer. Carefully insert the thermometer into the calf's rectum. Push carefully the thermometer against the intestinal wall, so that the thermometer not measure the temperature of the feces. Notice the time.

3. Vitality at birth (slö/normal/alert). Estimates when the first meal is given.

   Weak calfs lie down most of the time, needs to be lift up at feeding and are not active in search of food.

   Normal calfs stands up in 3-4 hours age and stand up spontaneously with feeding and have well working sucking reflex.

   Alert calfs stands up and walks in 1hours age and search active for food.

4. Disease - has the calf been sick during this time period - if yes, which disease?

5. Treatment - has the calf been treated for anything during this time period, if yes - for what and with what? Date?

6. During the time when cow and calf are together, does it only suckle or do you give supplementary meals milk with bottle? If yes - how many times and quantity? Specify if it is colostrum, transition milk or whole milk.

<u>Table - cow</u>

7. Quality of the colostrum - Brix% - see the “manual refractometer” for help with the measuring of the quality.

8. Treatment - has the cow been treated for anything during this time period, if yes - for what and with what? Date?

9. Supplement during dry period - for example Bovikalc, Xzelit or similar?

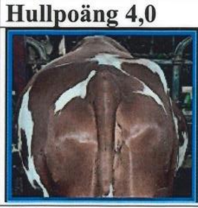
10. Calving difficulty. Evaluate as below.

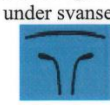
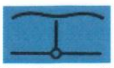
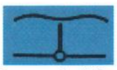
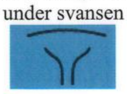
    11. Easy, without help
    12. Easy, with help
    13. Difficult, with help from veterinarian
    14. Difficult, without veterinarian

Appendix 3 Body condition evaluation schedule by Per Gillund

HULLVÄRDERINGSSCHEMA
efter material från Per Gillund, GENO

	Hullpoäng 2,0	Hullpoäng 2,5	Hullpoäng 3,0
			
Ryggkotornas uppåtgående utskott	Varje utskott syns tydligt, sågtandat intryck	Enskilda utskott syns	Enskilda utskott syns ej, ryggraden är tydligt benig
Området mellan uppåt- och sidogående ryggradsutskott	Djupt insjunket	Tydligt insjunket	Mjuk konkav kurva
Höftknölar och bärbensknölar	Skarpt framträdande	Tydligt framträdande	Jämnt, mjuka konturer
Svansgrop	U-formad grop under svansen	Fördjupning med tendens till fettlager	Grund med tunt fettlager

	Hullpoäng 3,5	Hullpoäng 4,0	Hullpoäng 4,5
			
Ryggkotornas uppåtgående utskott	Mjukt rundad rygglinje	Platt yta, inga synliga bendelar	Begravda i fett
Området mellan uppåt- och sidogående ryggradsutskott	Svag konkav kurva, nästan jämn sluttning	Nästan plan	Rundad uppåt, konvex
Höftknölar och bärbensknölar	Täckta med vävnad	Rundade med fett	Begravda i fett
Svansgrop	Grund med tydligt fettlager	Rundad, fylld med fett, antydning till veckbilding vid svansfästet	Begravd i fett, tydlig veckbildning vid svansfästet.

	Hull-poäng	Ryggkotornas uppåtgående utskott	Området mellan uppåt- och sidogående ryggradsutskott	Höftknölar och bärbens-knölar	Svansgrop
Kraftigt avmagrad, utmärglad	1.00	 Varje utskott syns tydligt, sågtandat intryck	 Djupt insjunket	 Mycket skarpt framträdande, endast skinn och ben	 Djup V-formad håla under svansen
	1.25				
	1.50				
	1.75				
Dåligt hull, tydligt framträdande skelett	2.00	 Enskilda utskott syns	 Tydligt insjunket	Tydligt framträdande	U-formad grop under svansen
	2.25				
	2.50	Enskilda utskott syns ej, ryggraden är tydligt benig		Något beniga	Första antydan till fettlager
	2.75				
	3.00		 Mjuk konkav kurva	Mjuka konturer	 Grund svansgrop med tunt fettlager
Medehull	3.25				
	3.50	Mjukt rundning över ryggraden, utskotten syns ej	 Jämn sluttning	Täckta av vävnad	
	3.75			Rundade med fett	
	4.00	Plan yta, inga synliga utskott	 Nästan plan		Fettfylld svansgrop, antydan till veckbildning av fett under svansen 
Fet, skelettet är täckt av fett	4.25				
	4.50		 Rundad uppåt, konvex		Svansgropen är fettfylld, veckbildning av fett under svansen
	4.75	 Begravda i fett		 Begravda i fett	
Mycket fet	5.00				

Appendix 4 Form used at farm visits

Questions for farmers

Calves

<u>Housing</u>

- The flow from birth - when/how do they move the calves and routines about it.

  Age in the different housing systems. Number of calves in each box. Any transfer between groups.
- Cleaning of the boxes.

<u>Management</u>

- Which feed do the calves got beyond milk - hay/pellets for example.
- Do they give colostrum to the calves on a routine basis - bottle, nippled bucket or bucket. Do they give transition milk. Do they use milk powder.
- Difference in routines if the calf is born during day or night.
- Lowest Brix (%) value on colostrum which they feed the calf with.
- Other milk routines during the first month - how much milk fed in each meal and how many milk feedings per day.
- Do they have same feed allowance during summer and winter.

Dry cows

<u>Housing</u>

- The flow from drying off until parturition - how do they move the dry dows.

<u>Management</u>

- How is the schedule at dry off.
- Routines around dry cow treatment.
- Do they have preventive treatment against milk fever.
- Do they milking out all colostrum first milking after calving? If not, how much do they approximately milking out.

<u>Feeding</u>

- Quantity of feed allocated to the dry cows per day. Free access of feed or how many feedings per day.
- Minerals - how much do they get. Is the ration changing during the dry period.
- Do they get straw and salt lick.

- How is the dry cows kept during summer. Feeding during summer - only pasture/extra feeding/minerals/salt.
- Changing of feeding during the dry period - far off/close up etc.

Pregnant heifers last month before parturition

Housing

- How do they move the heifers.

Feeding

- Quantity of feed allocated to the heifers per day. Free access of feed or how many feedings per day.
- Minerals - how much do they get. Is the ration changing.
- Do they get straw and salt lick.
- How is the heifers kept during summer. Feeding during summer - only pasture/extra feeding/minerals/salt.

Documentation during farm tour

Calves

Housing

- Calf huts or stable
- Single boxes/group boxes
- Number of calves/box
- Type of litter in boxes
- Water - bucket or water cups.

Dry cows

Urine sampling and body condition score

ID cow	Urine pH	Urine temperature	Body Condition score	Rumen fill score	Breast size	Far off/close up

Other comments on urine sampling and body condition assessment

Housing

- Occupancy rate at feed table. (Measuring feed table). Number of stalls.
- Deep straw bedding/loose housing? Loose housing- Warm or cold? Number of animals/box.

- Number of water cups/tubs.

Pregnant heifers last month before parturition

<u>Housing</u>

- Occupancy rate at feed table. (Measuring feed table)
- Number of stalls. Deep straw bedding?
- Number of animals/box.
- Number of water cups/tubs.