Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Veterinary Medicine and Animal Science
Department of Animal Nutrition and Management

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Uppsala
2016

Degree Project 30 credits within the Veterinary Medicine Programme

ISSN 1652-8697
Examensarbete 2016:52

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Jämförelse mellan tre utfodringsmetoder av råmjölk och dess effekt på överföring av immunitet, tillväxt och hälsa hos mjölkraskalvar

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Degree Project in Veterinary Medicine

Credits*: 30*
Level*: Second cycle, A2E*
Course code*: EX0755*

Place of publication*: Uppsala*
Year of publication*: 2016*
Number of part of series*: Examensarbete 2016:52*
ISSN*: 1652-8697*
Online publication*: http://stud.epsilon.slu.se*

Key words*: colostrum, oesophageal tube, feeding, bottle, suckling, growth, health, newborn, calves*
Nyckelord*: Råmjölk, utfodring, kalvhälsa, tillväxt, jämförelse, sondmatning, flaska, diande kalvar*

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SUMMARY

Transfer of passive immunity occurs in most animals across the placenta. In calves however, the maternal blood supply is separated from the calf. As a result, no in utero transmission of immunoglobulins occurs and the calves depends solely on ingestion of immunoglobulins from colostrum. In todays' non-organic commercial dairies, allowing calves to suckle is uncommon and has largely been replaced by artificial feeding methods such as bottle or bucket feeding since it is easier to control that all calves consume enough colostrum to ensure good transfer of passive immunity. However, bottle or bucket feeding can be time consuming and difficult when calves are not motivated to drink thus increasing the risk of failure of transfer passive of immunity. For this reason, some dairy farms have recently introduced oesophageal tube feeding (OT) as a routine for feeding colostrum to new born calves since it fairly quick and it is easier to ensure that all calves receive an appropriate amount of colostrum in their first meal. Previous studies have compared these feeding methods and showed that suckling calves have lower concentration of IgG in serum than artificially fed calves. However, in these studies each feeding routine was carried out in different farms all with different management routines making it hard to distinguish the effects of the feeding method from other management practices (such as general hygiene, housing, colostrum management etc.) that may have influenced the results. Furthermore, most studies comparing the three different feeding methods do not report growth rates or health of the calves. Therefore, the aim of this study was to compare the effects of three different colostrum feeding routines on the passive transfer of immunity, growth and health of newborn dairy calves that were handled in the same way (same farm, housing, management and staff). Sixteen new-born heifer calves were included in this study and randomly allocated to one of three different colostrum feeding methods: suckling its mother (suckling), bottle or oesophageal tube (OT) feeding. The calves were monitored for 2 weeks and feed intake, growth rate and health were recorded. In addition, IgG concentrations in the mothers' colostrum and in the calves' blood serum at 24 and 48 h after birth were measured using an ELISA technique. Due to the fact that only 16 calves fulfilled the criterions to be included in the study, no definite conclusions could be drawn from our results. When analyzing the results however, there were no significant differences between the different feeding methods in terms of serum IgG levels at 24h and 48h of age or calf health. The suckling group had a higher mean feed intake/meal during the first week compared to the tube fed group but growth rates were not different between the groups, at least until 14 days of age. From a management point of view, the only advantage of using an oesophageal tube to feed the calves was that the first feeding took significantly less time compared to feeding with a bottle. However, when calculating the overall time it took to feed the calves during the first four days, the difference was no longer significant. Furthermore, the time taken to feed the suckling calves was less than the OT group when including the meal where the suckling group remained with the mother. When reviewing our results and compared them to previous studies however, we concluded that the use of an oesophageal tube is a good way to ensure that calves that do not voluntary drink receive sufficient amounts of colostrum to resist infection. However, for feeding healthy calves with good motivation to drink OT does not appear to offer any advantages over bottle feeding or suckling in terms of transfer of passive immunity, health and growth. Based on these preliminary results, the routine use of OT feeding is hard to justify since it is an invasive procedure and denies them the opportunity to express their natural behavior of suckling without offering any clear health advantages.

SAMMANFATTNING

Hos de flesta däggdjur sker överföring av immunoglobuliner från modern till avkomman genom placentan under fosterstadiet. Vid kons dräktiget är dock moderns blodflöde separerat från kalvens. Konsekvensen blir att kalven föds utan immunoglobuliner och behöver få i sig dessa via råmjölken. Studier har visat att de viktigaste faktorerna som påverkar överföring av immunitet är mängden antikroppar som kalven får i sig samt när efter kalvning råmjölksutfodringen sker. Den allmänna rekommendationen är att ge kalvarna 3-4 L råmjölk inom 6 timmar efter kalvning. Att låta kalvarna dia naturligt tillåter inte den övervakning av volym och tid som krävs för att optimera råmjölksintaget. Därför används ofta olika metoder av artificiell utfodring för att säkerställa att kalvarna får i sig tillräckligt mycket råmjölk inom rätt tidsram. Tidigare har man visat att kalvar som lämnas till att dia ofta har en lägre koncentration av IgG i serum, vilket man tror beror på att de inte lyckas dia en tillräcklig mängd råmjölk inom de första, kritiska timmarna. För att vara säker på att kalvarna får i sig en stor mängd råmjölk under de första timmarna efter födseln används ofta flaskmatning. Detta är dock en tidskrävande utfodringsmetod, särskilt när kalvarna inte vill dricka frivilligt. Därför blir sondmatning en allt vanligare metod eftersom man med hjälp av sond kan utfodra en stor mängd råmjölk under kort tid. De metoder som vi undersöker i denna studie är sondmatning, flaskmatning och digivning. Tidigare studier har jämfört dessa utfodringsmetoder mellan olika gårdar men med tanke på att det kan skilja väldigt mycket i hantering och hygien mellan gårdarna så gjordes denna studie för att jämföra de olika metoderna när kalvarna hanteras av samma personal och hålls i samma miljö. Dessutom har de flesta tidigare studierna bara jämfört överföring av immunitet och inte tillväxt, hälsa och foderintag. Därför är syftet med denna studie att jämföra de tre utfodringsmetoder med avseende på tillväxt, hälsa och foderintag såväl som överföring av immunitet. Prover togs på råmjölken en timme efter kalvning samt serumprover från kalvarna vid 24 och 48 timmar efter födseln och analyserades för koncentration av IgG. Endast 16 kalvar uppfyllde kriterierna för att delta i studien, vilket resulterade i att inga signifikanta slutsatser kunde dras från försöket. I denna studie kunde vi ej visa några signifikanta skillnader på grupperna med avseende på hälsa, tillväxt och överföring av immunitet. Sondmatning visade sig vara en snabbare metod för att utfodra råmjölk jämfört med flaskmatning vid första utfodringen, men när resultaten för de första fyra måltiderna summerades var det istället digivning den minst tidskrävande metoden. De kalvar som fått dia hade ett högre foderintag den första veckan jämfört med de sondade kalvarna. Sammanfattningsvis kunde vi ej hitta några övertygande resultat som stödjer utfodring med sond när vi vägde våra resultat samt tidigare studier. Kalvarna bör få utöva sitt naturliga sugbeteende och sondmatning bör inte användas i annat fall än när det är absolut nödvändigt, vilket är när kalven inte dricker den rekommenderade råmjölksmängden frivilligt.

CONTENTS

INTRODUCTION

One of the keys for a sustainable dairy production is to ensure a continuous generation of healthy, high-producing replacement animals to maintain milk production. In Sweden, the average age of culled cows in 2014 was around 60-61 months (Växa, 2015). For example, in a farm of 200 animals, 40 new, healthy, female calves need to be recruited every year to match the loss of culling animals and maintain the high production rate. Therefore, it is crucial to implement management practices that promote health and survival of the calves to have enough new heifers available to match the high replacement rates. One of the biggest challenges to ensure enough replacement animals are available is calf mortality. In Sweden, a recent survey found that calf mortality between 1-60 days of age can be as high as 6% in problematic farms (Växa, 2015). It is widely known that the first few hours of the calf's live is of great importance to its future health and survival. One of the most important and fundamental factors that determines the health and survival of the newborn calf is adequate colostrum intake during the first meals (Weaver *et al.,* 2000). Since the calves are born with insufficient immunological defense due to lack of in-utero transmission of immunoglobulins it is essential that the calf gets enough maternal immunoglobulins (Ig) from the mothers' colostrum (Godden, 2008), the term for this transmission is passive transfer of immunity.

Because of the importance of calf survival, scientists worldwide have over many years tried to find factors that may improve the passive transfer of immunity. Today the common knowledge is that the volume of immunoglobulins ingested and the calves ability to absorb immunoglobulins are the main factors to consider in the colostrum feeding and management routine to improve the passive transfer of immunity (Michanek *et al.,* 1989, Stott *et al.,* 1979). It has been shown that the passive transfer of Ig across the small intestine of the calf is limited to the first 24 h of the calves' life and is greatest the first 6 h (Stott *et al.,* 1979). To make sure that the calves ingest a sufficient volume of colostrum within the right timeframe, farmers use different methods to feed colostrum to the newborn, all of which have pros and cons.

In todays' commercial, non-organic dairies, suckling calves have been replaced largely by bottle or bucket feeding (Persson Waller *et al.,* 2013). Suckling, which is the natural way of feeding, leaves very little room for surveying the volume of colostrum consumed by the calf as well as ensuring that the colostrum is drank before 6 h after birth. There are studies showing that a large proportion of calves do not manage to drink colostrum within 6 h after birth (Selman *et al.,* 1970). Therefore, it is not surprising that studies have found that letting the calf suckle results in a higher prevalence of insufficient concentration of Ig in serum, commonly known as failure of passive transfer of immunity or FPT (Brignole & Stott, 1980). FPT is defined by a concentration of IgG at <10 mg/ml in blood serum (Weaver *et al.,* 2000). In order to improve transfer of passive immunity, dairy farms use either a bottle or bucket to insure that the calves get the right volume of colostrum at the appropriate time. This has been shown to result in higher concentration of Ig in blood serum (Molla, 1978). Bottle or bucked feeding however, has been referred to as a time consuming method of feeding (Persson Waller *et. al.,* 2013). To avoid this problem, the use of an oesophageal tube has been introduced (Persson Waller *et. al.,* 2013). The use of an esophageal tube allows the farm staff to ensure that the calf drink enough colostrum within 6 hours postpartum as well as being a fast method of feeding. Despite the positive outcomes of using an oesophageal tube, It has also been suggested that calves fed with a tube does not want to drink voluntarily during the following meal (Persson Waller *et. al.,* 2013). Therefore, any time saved on the first meal may be lost by having to spend more time on trying to get the calves to drink their following meals. It can also be discussed that oesophageal tube feeding requires a considerable amount of handling and could possibly cause the animal stress and discomfort due to the possibility to feed the calves more than they voluntarily would consume (Kaske *et al.,* 2005). While there is a lot of evidence concerning the difference in passive transfer of immunity between the three methods of feeding (Brignole & Stott, 1980, Bush & Staley, 1980, Kaske *et al.*, 2005), there are very little research considering effects on the health, growth and feed intake. Therefore, the main purpose of this thesis was to compare the three different methods of feeding and their effect on health, feed intake and growth as well as evaluating the passive transfer of immunity in dairy calves.

Aims and hypotheses

The main aim of this thesis was to compare three different methods of feeding including oesophageal tube feeding, bottle-feeding and suckling and their effect on passive transfer of immunity, feed intake, health and growth in dairy calves. This will be achieved by investigating the following hypothesizes:

- Feeding dairy calves colostrum using an oesophageal tube will take significantly less time than when feeding with a nipple bottle.
- Calves fed with an oesophageal tube will have higher blood serum IgG levels than suckled and bottle-fed calves.
- Calves allowed to remain with their mother for 24 h will have higher blood serum IgG levels than calves in the bottle-fed group.
- The colostrum feeding method will not affect the feed consumption from the second meal up until one week of age.
- The colostrum feeding method will not affect the growth rate from birth to two weeks of age.
- The incidence of fever and diarrhea is higher in the suckling group compared to the oesophageal tube-fed calves.
- Low levels of serum IgG will be associated with high incidence of diarrhea or other disease.

LITTERATURE REVIEW

Transfer of passive immunity

During fetal development, the blood supplies of the mother and calf are separated by the placenta(Godden, 2008). As a result, the immunoglobulins remain in the maternal blood supply and the calf is born without protective immunoglobulins. To acquire a sufficient immunological defense, the calves depend solely on the passive transfer of immunoglobulins from the colostrum. The main immunological components in colostrum are IgG, IgM and IgE, along with maternal leucocytes and cytokines (Foley, 1978). IgG counts for 85-90% of the total immunoglobulins in colostrum is therefore the most researched of the immunoglobulins in relation to passive transfer of immunity.

Failure to absorb sufficient immunoglobulins is referred to as failure of passive transfer (FPT) and calves are deemed such when they have blood serum concentrations of less than 10 g/L of immunoglobulin G (IgG) (Weaver *et al.*, 2000). Calves with FPT are not defined as sick calves but they are more susceptible to infections than other calves and it has been shown that the prevalence of e.g. pneumonia, diarrhea and umbilical infection is higher in calves with FPT (Furman-Fratczak *et al.*, 2011; Wells *et al.*, 1996). It is therefore very important that the farmer adjust the routines so that the calves get their necessary colostrum.

Decades of research have led to the conclusion that passive transfer of immunity can be improved by adjusting the management of newborn calves at the farm. Naturally, there are many factors that contributes to a more efficient absorption of Ig in the newborn calves, the most important being the volume of colostrum ingested, the quality of the colostrum and the calves ability to absorb the immunoglobulins from colostrum. These are the challenges that the farmers need to address to perfect their routines in order to achieve high concentrations of Ig in their calves and thus, increase the chance of calf survival.

Volume of colostrum

The amount of Ig transferred from cow to calf is determined by three factors; the volume of colostrum ingested by the calf, the concentration of Ig in colostrum and the efficiency of absorption. Thus, the volume of colostrum needed to achieve sufficient concentration of Ig in serum depends on the concentration of Ig in colostrum and the intestines ability to absorb immunoglobulins. A general goal is to feed the calf 100g IgG in the first feeding(Godden, 2008).

Naturally, the farmer cannot know the exact concentration of immunoglobulins in colostrum to measure the volume required to reach 100g IgG. Therefore, general recommendations on colostrum volume have been suggested. These vary in between studies but is in general between 3-4 L(Godden, 2008, Hopkins & Quigley, 1997, Morin *et al.*, 1997). Other authors argue that the recommendation should depend on the weight of the calves rather than a specific amount. For example, one study showed that calves who were fed 7% and 10% of their bodyweight had less Ig in serum after 24 h than the calves fed 8.5%. This supports the statement that there is that there may be a linear relation between Ig in serum and the volume fed up to a certain point, after which the absorption declines (Conneely *et al.,* 2014). In Sweden, the general recommendation is to feed as much colostrum as possible, but at least 3 liters of colostrum to all dairy calves (Växa, 2015).

Colostrum quality

High quality colostrum is essential for achieving the goal of feeding the calves 100g IgG in the first feeding. Because of the well-understood relation between IgG and passive transfer of immunity, IgG is most often used as an indicator for colostrum quality. The concentration of IgG in colostrum varies widely among individual cows (McGuirk & Collins, 2004). Different studies have reported values ranging from 15mg/ml to 176 mg/ml. Colostrum is considered to be of high quality when the concentration exceeds 50mg/ml (Godden, 2008). Naturally, there are other factors influencing the quality as well, such as bacterial contamination and nutritional components.

Apart from individual variation, other factors may also influence the quality of colostrum. For example, the concentration of Ig in colostrum peaks immediately after birth and decreases over time after calving (Morin *et al.,* 1997). Therefore, farmers should aim to milk the cow within 1-2 h after calving and preferably not delay the milking to longer than 6 h after calving in order to achieve as high concentration of Ig in colostrum as possible (Godden, 2008).

As mentioned in the previous section, farmers cannot know the exact concentration of Ig in colostrum. However, some guidelines may give the farmer an estimate of the colostrum quality. For example, most research agree that milk for cows with mastitis should be avoided as well as colostrum with abnormal color or smell (Godden, 2008). It is also recommended to avoid using colostrum from cows who produces less than 8.5 kg of colostrum during first milking because they are more likely to produce colostrum with a concentration of less than 50 mg/ml (Pritchett *et al.,* 1991).

Even if these factors are helpful for the farmers, they can still not be sure if the colostrum has the right quality or not. Because of the importance of high quality colostrum, inexpensive and easy to use testing instruments are often used to evaluate the colostrum quality. The Brix refractometer is a commonly used tool for evaluating the quality of the colostrum. It is easy to use and it is not temperature sensitive. The Brix refractometers measures the specific gravity, which has been shown to be correlated to the IgG concentration (Bielmann *et al.,* 2010).

Time of feeding and efficiency of absorption

To understand the efficiency of absorption in newborn calves, a thorough understanding of the calves digestive system is essential. Newborn calves have a premature digestive system equivalent to a monogastric digestive system, which allows the passage of colostrum from the esophagus straight to the abomasum, thus skipping the rumen and allows faster absorption of nutrients (Goff, 2015). This bypass is commonly known as the oesophageal groove reflex. The absorption of large macromolecules, such as immunoglobulins, occurs in the small intestine.

The intestine is open to absorption of immunoglobulins from the small intestine only during a limited period after birth. The absorption rate is greatest immediately after calving and closes progressively during the following period until 24-36 h when the intestine is fully closed to absorption of Ig molecules (Bush & Staley, 1980). The time to closure can be increased if feeding is delayed, but at 48 h, the closure is complete even if the calf was deprived of food. The mean closure time has been evaluated to 24 h while not feeding calves can delay the period of absorption, early feeding of colostrum have been shown to shorten the period of absorption (Stott *et al.,* 1979).

The conclusion is that in order to be able to absorb as much Ig as possible, the calves need to receive the colostrum, preferably within the first 6 h after birth when the absorption rate is at its highest. At 12 h, the absorption slows down and after 24-36 h, the small intestine becomes impermeable for immunoglobulins (Bush & Staley, 1980).

Improving passive transfer of immunity

To achieve the goal of giving the calves' the recommended volume of colostrum within 6 h postpartum, different feeding techniques have been adapted in order to improve the passive transfer of immunity. Each of these colostrum feeding methods has different advantage and disadvantages related to the ease of controlling the quality, timing and volume of colostrum fed to the calves as well as in terms of the invasiveness of the procedure and these are discussed in detail below.

Suckling

Suckling the mother is the natural way of feeding calves and it has important beneficial effects on the physiology of the calves. For instance, the oesophageal groove reflex has been shown to be stimulated by suckling. As a result, the shunting of colostrum from the oesophagus directly to the abomasum allows faster absorption of immunoglobulins. This mechanism also prohibits the milk from remaining in the rumen to sour and possibly lead to bacterial fermentation (Lateur-Rowet & Breukink, 1983; Radostits *et.al.,* 2007).

Suckling also leads to a difference in hormonal release compared to calves who are not allowed to suckle. Calves that suckle have a higher oxytocin release than calves that drink from a bucket as well as a significant decrease in cortisol levels 30 minutes after feeding compared to calves that were denied suckling (Lupoli *et al.,* 2001). The authors explained the decrease in cortisol combined with the higher release of oxytocin as an anti-stress response, meanwhile, the cortisol levels indicated that the calves might experience some level of separation stress. (Lupoli *et al.,* 2001).

Moreover, it has been suggested that cortisol may have a negative effect on the small intestine and the absorption of immunoglobulins. This has been studied and proved in other animals e.g. mice and horses, but there is a lack of evidence if this is the case with calves. When keeping calves from eating, the cortisol levels will be elevated and a negative correlation between cortisol and IgG concentration were found in food deprived calves (Nightengale & Stott, 1981). However, the evidence was week and another study showed no significant changes in immunoglobulin absorption in relation to cortisol (Stott & Reinhard, 1978).

Suckling also have a positive effect on the mothers. For instance, cows who has a suckling calf present have a higher milk-production than machine-milked cows (Bar-Peled *et al.,* 1995). The same study also showed that cows with suckling calves had higher level of oxytocin and prolactin compared to the machine-milked cows.

Apart from the physiological importance, the act of suckling is also a deeply rooted behavioral trait. As soon as the new-born calves manages to achieve a standing position, the next thing they do is searching for the teat (Selman *et al.,* 1970). The teat-search is greatest between birth and the first suckling. The time spent searching depends on the shape of the mother and during a behavioral study, the calves spent around 19 minutes searching for the teats (Selman *et al.,* 1970). The same study showed that 76.7% of the calves started suckling within 8 h.

Even though there are evidence of beneficial consequences to letting calves suckle, the routine results in poor control over the colostrum intake and has been shown to lead to high rate of FPT (Brignole & Stott, 1980, Kaske *et al.,* 2005). For example, one study of 10 calves who were allowed to suckle for 24 h, showed that 30% of the calves had a serum concentration of IgG less than 4 mg/ml (Klaus *et al.,* 1969). These findings are not surprising considering the relatively high percentage of calves that does not manage to suckle before 8 h. In todays' commercial dairies, leaving the calves to suckle is becoming continually less popular. Ever since the importance of passive transfer of immunity was recognized, other methods of feeding have been recommended to make sure that the calves get enough colostrum during the first 6 h of the calves' lives. To solve this problem, many farmers use a bottle with nipple or a bucket to feed the calf its first meal.

Bottle feeding

The use of a bottle to feed the calves allows the staff to ensure that the calves be fed a specific amount of colostrum as well as allowing the calves to perform the natural behavior of suckling and thus benefit from the positive effects of suckling. Additionally, if the cow is milked, and the colostrum tested closely after calving, the farmer can get a good idea if calf received a good amount of IgG or not.

The use of a bottle, unlike feeding from a bucket, allows the animals to learn how to suckle and faster get used to an artificial nipple. This method also allows the oesophageal groove to close and the milk to be shunted to the abomasum, leaving no fluids in reticulorumen.

When researching the IgG concentration in serum following suckling compared to bottle feeding in three different farms, one study found a higher prevalence of FTP in the suckling farm than in the farms using bottle feeding or tube feeding (Besser *et al.,* 1991). However, another study on bottle feeding versus suckling showed a higher absorption rate and concentration of IgG in serum at 24 h postpartum (Stott *et al.,* 1979).

Although bottle feeding is a good way to be sure the calf gets enough colostrum, it can be argued that the process is not very time-effective for the farm staff. Some calves may take the bottle straight away and eat non-stop for a few minutes while other calves can take a lot of time to feed. To avoid the time-consuming bottle-feeding, and still make sure the calves receive the large amount of colostrum needed, the use of tube feeding has been recommended (Kaske *et al.,* 2005; Molla, 1978).

Oesphageal tube feeding

Using an oesophageal tube allows the staff to pour the desired amount of colostrum straight into the oesophagus without letting the calf suckle. This is considered a more time-efficient way of feeding colostrum to the calves but there are also some possible negative aspects that should be considered.

The use of oesophageal tube feeders prevents the oesohageal groove reflex (Lateur-Rowet & Breukink, 1983). As a result, the milk ingested enters the rumen instead of the abomasum (Labussiere *et al.,* 2014). This is commonly referred to as failure of oesophageal groove reflex,and it is not an uncommon condition in dairy calves and is often associated with the term ruminal drinkers. Ruminal drinkers are often presented with various symptoms including tympanism, clay-like feces and inappentence (Radostits *et al.,* 2007).

Another factor to consider while discussing tube feeding is the possibility to feed the calves more colostrum than they voluntarily would consume. The common recommendation is to feed 3-4 L of colostrum during the first 4 hours of the calves' life. However, when fed colostrum with bottle, calves rarely drink more than 2.5 liters voluntarily (Kaske *et.al.,* 2005).

During a study performed at Utrecht university it was discovered that the mean volume of the abomasum of a calf approximately 2 hours after birth was 2.74 L (Hamersma, 2014). There were no correlations between the volume administered and the abomasal volume. This indicates that there is little or no stretching of the abomasum when fed larger volume, and thus, the excess volume that does not fit in the abomasum ends up in reticulorumen.

MATERIAL AND METHODS

The study was carried out at Lövsta research center. Lövsta is a part of the Swedish University of Agrucultural Science and is a dairy farm with approximately 300 producing cows in loose housing.

Animals

Sixteen female calves were included in this study, all were healthy and weighed at least 30 kg at birth and born without difficulties. The breeds used in this study were Swedish Holstein and Swedish Red. The mothers were healthy, multiparous cows with no mastitis and good quality colostrum of at least 20% Brix and that produce enough colostrum for the calf's first meal (8.5% of the calves' bodyweight).

Housing and management

The mothers were placed in calving boxes prior to calving and fitted with udder nets to prevent suckling before the first feeding. After birth, the calf and the mother were allowed to stay together for at least two hours to interact with each other and allow the cow to groom the calf. The cow was milked in the calving stall with the calf present one hour after calving to ensure that the cow produced sufficient colostrum for the first feeding. The colostrum was kept in the milking container and placed in a cooling room at approximately 4°C. Except for milking the cows, the cow and calf were allowed to stay together undisturbed until the calf was taken out to be weighed in a portable scales and moved to a different room inside the same barn for the first feeding. Before the feeding, the colostrum was slowly heated up to 37-40°C before it was given to the calf. The person performing the feeding placed the calf between the legs and held the head with one hand and the tube or bottle in the other hand. The feedings were performed in a room separated from the mothers where they could not see or hear each other. After the feeding, the calves were moved to single pens and kept there for seven days, except for the suckling calves who returned to their mother. Water, hay and concentrate were always available to the calves. In the single pens, the following meals were fed at 12 hour intervals using a bucket with a nipple and the calves received approximately 3000g colostrum. All the pens were kept clean and bedded with sawdust. At eight days of age, the calves were move to outdoors calf hutches with straw bedding. The calves had water and hay ad libitum and were fed 3 L milk in the morning and 3 L in the afternoon (12 h intervals) with nipple buckets. Concentrate was always available and consumption was recoded.

Treatments

The first meal of the calves' lives will further be referred to as the treatment, except for the suckling group, where treatment also includes the time spent with the cow and allowed to suckle freely. The first meal was given at 4 h after birth and 10 calves were offered 8.5% of their bodyweight in colostrum. Because of a lack of calves available for the project, we also had to include six calves from the pilot study that were offered 10% of their bodyweight in colostrum. All calves received colostrum from their own mothers. Calves were randomly allocated for one of the following treatments:

Oesophageal tube feeding

The oesophageal tube feeding (OT) group received colostrum using the coloquick feeding system. Coloquick consists of a stainless steel tube (length: 39.8 cm, diameter: 12 mm, head of the probe: 1.6 cm), which was connected to a plastic bag. The tube was inserted carefully in the calves' mouth and slowly placed in the oesophagus. The position of the tube was confirmed through palpation of the tube on the ventral side of the calves' neck. Only after securing the correct position of the tube, the contents were poured into the calf, preferable with the calf in a standing position.

Bottle feeding

The group in the bottle feeding group were fed using the Easy-Feeder nipple bottle. The suckling reflex was stimulated with fingers introduced to the mouth of the calf to stimulate suckling immediately before placing the nipple bottle in the calfs' mouth. If the calves stopped suckling the calf was given sufficient time to recover if coughing but if the calf actively looked to suckle, the nipple bottle was made available immediately.

Suckling

The suckling group was given the first meal in the same way as the bottle fed group. As a result, 10 calves were fed their first meal with a bottle. The difference for the suckling group was that instead of being placed in single pens, the calves were allowed to return to their mothers for 24 h after the feeding. During those 24 h the calves were allowed to suckle freely and interact with the mother. After 24 h, the calves in the suckling group were moved to single pens.

Data collection

Colostrum and milk samples

Colostrum samples were taken 1 h after calving. The brix values were recorded and the samples were placed in a freezer at -20°C immediately after sampling. The samples were stored in the freezer from sampling until they were unfrozen immediately before analyzing.

Feed intake

After each meal, including the treatments, the volume of milk offered to the calves as well as leftovers, and the time it took to feed the calves were recorded during the first week of after birth. However, when summarizing the data, we discovered that some feedings lacked both measurements of volume fed and leftovers as well as calculated time it took to feed the calves. Furthermore, the calves were given concentrate in addition to the milk feedings. The concentrate given was recorded by the farm staff.

Health outcomes

The calves' body temperatures were measured in the mornings every day during the first week around the morning feeding. Temperatures that exceeded 39.2°C were considered fever. Every morning the pens were checked for faeces. The faeces were scored by the farm staff using a score sheet (see attatchement 2).

The calves' bodyweights were measured at birth as well as at 1, and 2 weeks of age to evaluate the growth rate.

IgG analyzes

The IgG levels were measured using the Bethyl sandwich ELISA E11-118 kit. The samples were taken at the farm using a BD Vacutainer system and 10 ml BD Vacutainer serum tubes. The tubes were left on a bench for 25 min at room temperature to coagulate. The tubes were then centrifuged using the Labofuge 400R, function Line, Heraeus. The tubes were centrifuged at 4000 RCF for 10 minutes and the temperature were set to 4°C. After spinning the tubes, the serum was carefully pipetted into clean tubes before storing them in -20 degrees during the period from sampling to analyzing.

The blood samples were unfrozen in a cold water bath immediately prior to analysing. The serum was diluted using a dilution buffer, which was included in the kit, in 3 steps to achieve a 1:250 000 dilution. The tubes were carefully mixed after each dilution. 100µml of each standard or sample was added to designated wells. Duplicates were made from every sample. The plates were then left to incubate in on a microtiter plate shaker. After one hour, the plates were washed using a plate washer and 1X Wash Buffer.

After washing, 100µl of Detection antibody was added to each well. The plate was thereafter incubated for one hour at room temperature before washing it four times again as previously described. Afterwards, 100 µl HRP solution were added to the wells before incubating the plates for 30 minutes in room temperature. After incubation the plates were washed again four times using the previously described technique. After the final washing, 100µl of TMB Substrate Solution was added to the wells, and the color turned blue.The plates were incubated for 30 minutes in the dark at room temperature. After removing the plate from the final incubation 100µl of the stop solution were added to the wells and the plates were placed in a Multiskan FC plate-reader which delivered the result through a computer. The standard curve was analyzed and a mean value from the two samples were calculated.

The colostrum samples were stored in the freezer from sampling until the evening before analyzing when they were placed in a refrigerator to slowly unfreeze. In the morning, the colostrum was heated up slowly to room temperature in a water-bath. The colostrum samples were analysed using the same protocol and Bethyl Bovine IgG ELISA kit as were used for the serum samples, the dilution for the colostrum samples however, was 1:500 000.

Statistical analysis

The statistical analysis was performed to test the hypothesis described in the introduction and will be described in further detail bellow.

The time spent feeding the calves were analyzed using a one-way ANOVA with the time as a response to the treatment. The analyze was performed for the first four feedings separately as well as for the total time during the first four feedings including the treatment. The data is presented as mean values with standard deviation.

To determine the passive transfer of immunity and compare it between the groups, we used one-way ANOA with the IgG concentration in serum as response to the treatment.

The difference in feed intake during the treatment was analyzed using a one-way ANOVA with the volume of colostrum ingested as a response to the treatments. The following meals were also analyzed using a one-way ANOVA. The difference in growth rate between the groups were analyzed using a one-way ANOVA with the growth as a response to the treatment.

To evaluate the health of the calves and investigate any differences between treatments as well as serum IgG concentration, the cumulative incidence of fever and diarrhea were calculated with the defined period of time set to the first 7 days after birth. The cumulative incidences were compared between the groups using a one-way ANOVA.

All the statistical analyzes were performed using Minitab 7X statistical software. P-values $<0,05$ were considered statistically significant and P-values <0.09 were defined as tendencies. Data are means ± standard deviation. Outliers were tested using the Grubb’s test function in minitab.

RESULTS

Time spent feeding

The results of the time it took to feed the calves are presented in table 1. Because of the fact that the suckling group and the bottle group got the exact same treatment they are both presented as bottle treatment during the first feeding. When summarizing the data, we found some reports missing that the farm staff did not record, which is the reason for the difference in number of calves in the table below.

Table 1. *Time taken to feed calves during the first four meals.*

	Treatment		
	OT	Bottle	Suckle
First feeding			
Number of calves	6	10	-
Mean time(mm:ss)	5:02 ± 01:24	11:44 ± 06:14	-
Mean volume (kg)	3.56 ± 0,60	2.88 ± 0.91	-
Second feeding			
Number of calves	6	5	-
Mean time (mm:ss)	12:09 ± 05:03	10:23 ± 07:45	-
Mean volume (kg)	1.09 ± 1.05	2.33 ± 0.83	-
Third feeding			
Number of calves	5	5	5
Mean time (mm:ss)	10:01 ± 02:28	09:01 ± 03:51	05:30 ± 02:13
Mean volume (kg)	1.09 ± 1.05	2.65 ± 0.505	2.84 ± 0.22
Fourth feeding			
Number of calves	6	5	4
Mean time (mm:ss)	08:31 ± 01:58	07:46 ± 03:36	06:57 ± 03:01
Mean volume (kg)	2.10 ± 0.92	2.56 ± 0.67	2.76 ± 0.42
Total for the first four feedings			
Number of calves	5	5	4
Total time taken to feed the first four meals	37:38 ± 07:23	38:21 ± 15:30	24:27 ± 06:39
Mean volume (kg)	2.19 ± 1.24	2.68 ± 0.67	2.79 ± 0.62

There was a significant difference in feeding time between the groups during the first feeding (p=0,046). The average time it took to feed the calves with an oesophageal tube was 5:02 minutes and the average time for bottle feeding was 11:44 minutes, however, the results were very individual. While some calves took more than 20 minutes to feed with a bottle, there was one calf who took less than 5 minutes to feed.

The second feeding, the calves previously fed with oesophageal tube spent a mean time of 12:09 minutes drinking from the bucket, while the calves previously fed with a bottle spent an average of 10:23 minutes. The difference was not significant.

The third feeding, the suckling group spen an average of 5:30 minutes eating, meanwhile the oesophageal tube group spent over 10 minutes eating. This finding was a tendencie, but not statistically significant (p=0.073). The fourth feeding, there was no statistical significance nor a tendencie. When analyzing the total time for the first four feedings, the OT group spent an average of 37:38 minutes eating while the bottle fed group spent an average of 38:21 minutes and the suckling group an average of 24:27 minutes, but the difference was not statistically significant. The following meals had too few reported recordings and could not be statistically analyzed.

Transfer of passive immunity

Serum and Colostrum IgG

The mean IgG concentrations at 24 and 48 hours are presented in table 3, along with the mean volume colostrum consumed during the first 24 hour, brix values and the mean IgG in colostrum. One of the serum samples from the calves were missing, which is why there is only five calves in the oesophageal tube group.

Table 2. Mean concentration of IgG in serum at 24 and 48 hours, mean colostrum IgG, Volume consumed and mean Brix% value

	Treatment		
	OT	Bottle	Suckle
Number of calves	5	5	5
Mean serum IgG concentration at 24h (mg/ml)	51.0 ± 18.12	48.6 ± 12.74	31.9 ± 15.49
Mean serum IgG concentration at 48h (mg/ml)	50.1 ± 12.17	47.9 ± 11.95	30.31 ± 12.60
Mean colostrum IgG concentration (mg/ml)	121.1 ± 50.11	110.0 ± 44.95	89.5 ± 20.74
Mean volume of colostrum consumed during 24h (g)	5.40 ± 1.23	5.50 ± 0.80	2.97 ± 1.0*
Mean Brix value %	24.5 ± 2.65	24.1 ± 4.08	25.2 ± 4.00

** The volume ingested while suckling the dam was not recorded, therefore this is the minimum volume of colostrum the calves drank during the first 24 h.*

The mean IgG concentration in serum at 24 hours were 51,03 mg/ml in the OT group, 48.6 mg/ml in the bottle group and 31.89 in the suckling group. The difference in serum concentration was not statistically significant (p=0.15) although the concentration was highest in the OT group and lowest in the suckling group. The difference in IgG concentration had a strong relation to the concentration in colostrum (p=0.004).

Health outcomes

Feed intake

When summarizing the data, we had to exclude the feeding of concentrate from the results due to lack of reported data. The mean feed intakes during the first meal as well as the mean volume consumed per meal during the first week are presented in table 3. An outlier was detected in the suckling group using Grubb's test (G=2.79, p=0.015) for the total amount of colostrum consumed. However, excluding this calf did not make a statistically significant change in the IgG, health or growth results in so it was still included in all the analyses.

Table 3. *Mean feed intake of colostrum at first feeding and mean intake each meal during the first week*

	Treatment		
	OT	Bottle	Suckle
Colostrum intake at first feeding			
Number of calves	6	5	4
Mean birthweight (kg)	41.6 ± 4.5	40.7 ± 2.3	39.8 ± 5.9
Mean colostrum intake (kg)	3.36 ± 0.6	3.17 ± 0.4	2.96 ± 1.0
Mean colostrum intake (% of BW)	8.5 ± 0.8	7.8 ± 0.8	7.35 ± 2.0
Mean colostrum + milk intake/meal during all meals the first week (kg)	2.68 ± 0.11	2.89 ± 0.08	2.96 ± 0.06

The mean feed intake in the oesophageal tube group was 8.5% of their bodyweights, meanwhile the bottle fed group and the suckling group had a mean voluntary feed intake of 7.1% and 6.5% of the bodyweight. The difference was not significant, but worth mentioning since the recommended volume to feed calves exceeds the mean voluntary feed intake.

The calves who were fed with an oesophageal tube drank significantly less milk per meal during the following meals up to one week than the suckling and bottle groups (p=0.001) as illustrated in figure 1.

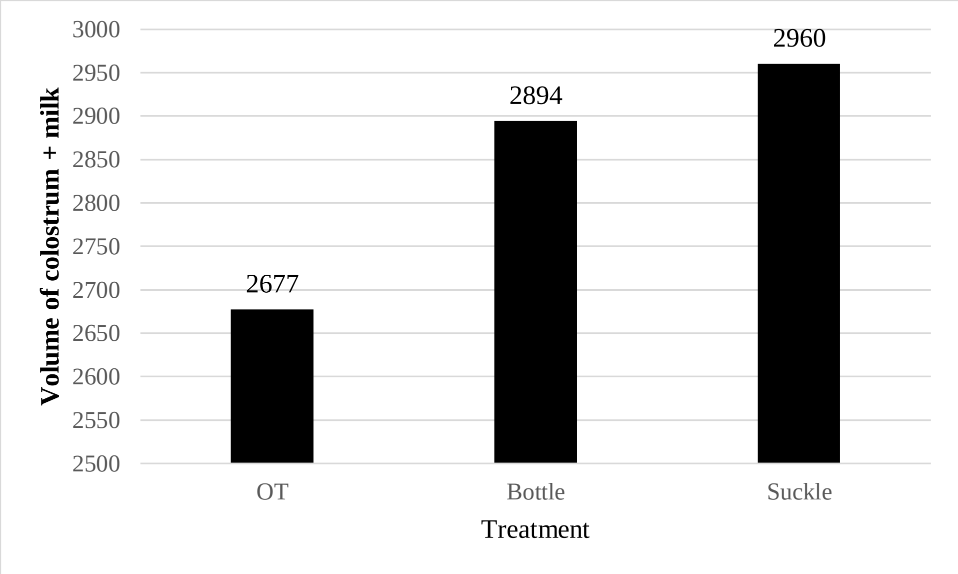

Figure 1. *Mean volume of colostrum + milk ingested each meal during the first week after birth. The treatment groups are presented on the X-axis and the volume (g) on the Y-axis.*

Growth rates

The mean growth rates of the calves are presented in figure 2. Because of lack of reported data by the farm staff, one calf from the oesophageal tube group and one calf from the suckling group had to be excluded from the results.

Table 4. *Mean growth rate during the first 2 weeks calculated as kg/day.*

	Treatment		
	OT	Bottle	Suckling
Number of calves	5	5	4
Mean birthweight (kg)	41.8 ± 5.0	40.72 ± 2.3	42.2 ± 2.6
Mean growth rate (kg/day)	0.84 ± 0.11	0.76 ± 0.34	0.76 ± 0.12

Although the results show a slightly higher growth rate in the OT group, the differences between the groups were very small and not statistically significant.

Temperature and diarrhea score

Only three calves in each group had properly filled charts of fever and diarrhea. The cumulative incidence of fever and diarrhea are presented in table 7. Due to a low number of calves with reported data, no calculation of incidence, nor proper statistical analysis could be performed. A total of eight calves out of 10 were presented with symptom of diarrhea and/or fever. All cases of diarrhea was mild (diarrhea score 1) except for one calf in the OT group who had diarrhea score 2. The calves showed symptoms for a maximum of 3 days. One of the calves in the suckling group had both fever and diarrhea.

Table 5. *Incidence of fever and diarrhea compared to IgG levels*

	Treatment		
	OT	Bottle	Suckling
Incidence of fever and diarrhea			
Number of calves	4	3	3
Number of calves with diarrhea	3	2	2
Number of calves with fever	0	1	1
Number of calves with fever and diarrhea	0	0	1
Serum IgG			
Number of calves	4	3	3
Mean serum IgG concentration at 24h (mg/ml)	43.53 ± 7.95	51.52 ± 15.99	32.58 ± 20.70

DISCUSSION

The aim of this study was to compare three feeding methods including oesophageal tube feeding, bottle feeding and suckling and evaluate the effect on feed intake, passive transfer of immunity, health and growth. Our results shows that the only advantage of using an oesophageal tube to feed the calves was that the first feeding took a significantly less time compared to feeding with a bottle. Although, when calculating the overall time it took to feed the calves during the first four meals, the difference was no longer significant. Considering the fact that suckling requires no time from the farm staff, allowing calves to suckle was actually less time consuming than tube or bottle-feeding. Furthermore, we could not find any statistically significant evidence that the feeding methods tested differed from each other in terms of calf health and growth. All calves had adequate transfer of passive immunity across the three treatments. The conclusion drawn from these findings, with the support from previous studies, was that there was not enough evidence to justify oesophageal tube feeding since it is an invasive procedure and also denies the opportunity to suckle.

Time spent feeding

The main argument promoting oesophageal tube feeding from the management point of view is that it is a fast way of feeding calves. Our results showed that feeding the first meal with an oesophageal tube was a faster way of feeding compared to feeding with a bottle. When feeding the second meal at the bucket however, the mean feeding time was actually longer for the calves that were previously fed with an oesophageal tube. When analyzing the total time spent feeding the calves the first four meal, the mean time spent feeding the suckling group was much shorter. Because of the low number of calves however, we could not prove if the results was significant. However, similar results of calves fed with artificial nipples compared to suckling calves has been seen in older calves (up to one year of age) (Veissier, 2013). Naturally, the suckling group required no staff handling them when suckling the second meal, and therefore the total time is less for that group. However, when removing the second feeding from the results, the time spent feeding the suckling group was still less than the time spent feeding the OT group. A possible cause to why the oesophageal tube group spent more time eating at the bucket could be because they did not know how to suckle and/or had a reduced suckling motivation. Previous research suggests that calves who are deprived of suckling preforms more nonnutritive suckling than calves fed milk from an artificial nipple. It has also been proved that nonnutritive suckling in calves reduces their motivation to suckle (de Passille, 2001), thus the calves in the suckling group may spend more time licking e.g. the interior of the pens and thus the motivation to suckle declines after the first meal. The conclusion we can draw from this is that it is more time efficient to feed the calves using an oesophageal tube when only the first meal is considered. However, when adding the following meals to the equation, the difference is small, which means that there is actually not so much time to be saved in the long run when oesophageal tubes are used.

Passive transfer of immunity

The main hypothesizes considering the passive transfer of immunity was that the calves in the oesophageal tube group would have a higher concentration than the other groups. This was proven to be true, although the difference was not statistically significant and therefore should not be considered as a main factor for promoting the use of oesophageal tubes. The difference in IgG concentration in serum had a strong relation to the concentration in colostrum (p=0.004). The conclusion is that the colostrum quality is more important for the passive transfer of immunity than the method of feeding.

All calves included in this study had a serum concentration of IgG that exceeded the FPT limit of 10 mg/ml. The calves' serum concentration of IgG varied between 17.65 mg/ml to 81.15 mg/ml in blood serum. Even though other authors have found individual calves with similar IgG concentrations, the concentration was overall higher than previous studies (Adams *et al.* 1985; Brignole & Stott, 1980). The reason behind the high IgG concentration could be explained by the fact that all colostrum was tested and had a very high quality. However, a more likely explanation could be differences in the analyze methods. In previous studies lower serum concentrations has been found when using methods with higher sensitivity, including radial immunodiffusion (RID) and turbidometric-immunoassay (TIA) (Swan *et al.,* 2007; Bielmann *et al.,* 2010). "

All cows produced high quality colostrum with IgG concentrations exceeding 50 mg/ml. The colostrum concentration varied from 65.53 to 208.17 mg/ml. The mean concentrations were 121.1, 110.0 and 89.5. The individual concentrations are within the variations seen in previous studies, but the mean colostrum concentrations are higher than other studies using the gold standard (RID) (Adams *et al.,* 1984; Bielmann *et al.,* 2010; Besser *et al.,* 1984). The high mean concentrations could be explained by the fact that only cows with good quality colostrum were selected for this study. However, considering the fact that the IgG concentration in serum was higher than other studies as well, this supports the theory that the analyze method could be faulty. Another interesting notice was that the Brix values did not correlate to the IgG concentrations in colostrum in the suckling group. The reason seemed to be two samples where the Brix values were high (31.10% and 26.50% and the ELISA results were not as high (108.8 mg/ml and 61.5 mg/ml). It is hard to know the reason behind this difference. It could be human error, where the results were interpreted faulty or failure of the refractometers ability to read due to an excess of light or insufficient cleaning. It could also be errors in the ELISA analyze as discussed previously.

One interesting discovery while discussing the passive transfer of immunity was that the suckling group had a lower serum concentration of IgG than the other groups considering our hypothesis being that the suckling group would have a higher IgG concentration in serum than the bottle group. The first meal of the suckling and the bottle fed groups were essentially the same, which in theory would mean similar serum concentrations. One reason that could possibly explain this is that the mean concentration of IgG in colostrum was greater in the bottle fed group (110.0 mg/ml) than in the suckling group (89.5 mg/ml). However, the difference in colostrum IgG was small and considering the fact that the bottle fed group was allowed to suckle, and therefore had the option to drink more milk than the bottle fed group, it seemed more likely that the suckling group would have a higher concentration of IgG in serum than the bottle fed group.

Another important notice is that one calf found to be an outlier when analyzed the feed intake during the first meal, was also the calf with the lowest IgG level. It is quite likely that this calf, due to its low colostrum intake, is one of the factors explaining the lower mean IgG value in the suckling group. Another likely explanation could be that the suckling calves did not spend enough time suckling to match the volume that was ingested by the other groups. If our IgG results indeed are falsely high (as discussed previously), it is possible that this calf actually is below the threshold for FPT.

Health outcomes

Feed intake

The first meal was either fed using an oesophageal tube or a bottle. Because of previous statements implying that calves in general do not voluntarily consume more than 2.5 L (Kaske *et al.*, 2005) when fed with a bottle our hypothesis was that the voluntary volume of colostrum consumed in the bottle group would be less than the 8.5% of bodyweight that is recommended for tube feeding. This was true for the calves in our study. Due to the low number of animals, no significant conclusion could be drawn, but only 1 calf out of 10 consumed 8.5% of its bodyweight in colostrum during the first meal. Recent studies showed that calves rarely consumed more than 2.5 L (Kaske *et al.*, 2005). In this study however, only 2 calves out of 10 refused to drink more than 2.5 L. The mean volume of colostrum fed to the oesophageal tube group was 8.5% of the bodyweight meanwhile the mean voluntary colostrum intake in the bottle group was 7.1%. In conclusion, while considering other studies along with our results, the volume of colostrum recommended for tube feeding exceeds the volume that the calves voluntarily drink.

One important observation was that one calf in the suckling group drank significantly less colostrum than the other calves and was considered an outliner. Meanwhile the recommended volume of colostrum to ingest compared to the bodyweight should be 8.5%, this calf only drank 2.6 % of its bodyweight. As a result, this calf had the lowest IgG levels in serum at 24 h. Furthermore, this was the only calf that had both fever and diarrhea. One likely possibility could be that the calf was sick even before the first feeding and was therefore too weak to drink the recommended volume.

Another major hypothesis considering feed intake was that the treatments would have no significant effect on the feed intake the following meals up to one week of age. This hypothesis was proven to be false. Even though there was some loss of data, there was a statistically significant difference between the oesophageal tube group and the suckling group. The group who got the oesophageal tube treatment ate significantly less than the other calves. The reason behind this difference could be a decreased suckling. Studies have shown that calves who are not allowed to suckle does more cross-suckling than calves who are allowed to suckle (de Passille, 2001). Furthermore, cross-suckling or nonnutritive suckling results in a decreased suckling motivation which could explain the reason to why the oesophageal tube fed calves ingested less than the other calves. It is also possible that the other calves who were fed using a bottle were already familiar with the artificial, and in the case of the suckling group, real teat and had therefore knew how to suckle. Another possible factor, which is very hard to prove, is that oesophageal tube feeding might damage the pharynx and/or the oesophagus, which could possibly cause the animals discomfort during the following meals. This is a difficult hypothesis to prove, and more research needs to be done considering the possibility of physical damage to the pharyngeal and oesophageal tissue.

Growth rates

The growth rates of the calves were very similar between the groups, which is consistent with other studies (Furman-Fratczak *et al.*, 2011; Veissier, 2013). The hypothesis was that the treatments would have no effect on the growth rates of the calves during the first 2 weeks, and we could not find any evidence to contradict this. Even though the calves in the oesophageal tube group had a lower mean feed intake/meal during the first weeks, they were the ones who had a slightly higher growth rate. This is likely a result of an increased ingestion of concentrate, however, due to very little recordings of concentrate intake, this statement could not be proven.

Temperature and diarrhoea score

When evaluating the calf healt within the groups, we looked at temperature and diarrhea. Unfortunately, some of the calves did not have properly filled charts, which lead to insufficient results that could not be statistically analyzed. Our results however, showed that 7 out of 10 calves had mild diarrhea, meanwhile two calves had fever. The calves that had diarrhea was evenly distributed between the groups and no pattern could be detected in terms of passive transfer of immunity and fever or diarrhea except for the one outlier calf who was the only calf with both fever and diarrhea.

CONCLUSION

This study provides a comparison between three methods of feeding and the effect on passive transfer of immunity, feed intake, health and growth. However, due to a low number of animals, no statistically significant differences could be proven because of the high possibility of individual variation.

Allowing the calves to suckle is a natural and deeply rooted trait and the calves' should not be denied to suckle if it is not necessary. This study showed no evidence proving that calves allowed to suckle for 24 h after being bottle fed, differed from the other groups considering growth and passive transfer of immunity. On the contrary, calves who were allowed to suckle their dam had a higher mean feed intake during the first week compared to the oesophageal tube group.

Bottle feeding did not show any differences from the other groups considering passive transfer of immunity, growth rate and feed intake. However, as previously stated, bottle feeding has been considered to be time consuming. This study showed that it indeed takes longer to feed calves with a bottle than with an oesophageal tube, although, when summarizing the time for the first four meals, the least time consuming method of feeding was suckling.

Even though we found no difference between the groups considering the IgG levels and health of the calves, it is worth mentioning that one calf drank significantly less colostrum than the other calves. As a result, this calf had the lowest IgG levels in serum, as well as being the only calf with both fever and diarrhea. It is possible that a larger volume of colostrum ingested at the first feeding could have helped to prevent fever and diarrhea which would support the previous arguments of the importance of a feeding a sufficient volume of colostrum to the calves.

Even though our study lacked the number of animals to prove our hypotheses, our results with the support of previous research supports that calves should not be denied to suckle if not absolutely necessary. The use of an oesophageal tube feeder should not be adapted regularly. However, special cases may require the use of the oesophageal tube. If the calves do not voluntarily drink enough colostrum from the bottle, the tube should be used to prevent low levels of IgG and thus the lower incidence of fever and diarrhea.

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Attachment 1

Pen: _______________ Tie stall Calf Colostrum feeding project

Calf ID: ____________ Birthdate:___________ Time (24 h): ____________ Mother:_______________

		Mothers Colostrum		Milk taxi				
		Day1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
	Date:							
AM	Time of feeding (hh:mm)							
	Amount fed (g) / leftovers (g)	/	/	/	/	/	/	/
	Time taken to feed (mm:ss)							
PM	Time of feeding (hh:mm)							
	Amount fed (g) / leftovers (g)	/	/	/	/	/	/	/
	Time taken to feed (mm:ss)							

	Concentrate feed (g)							
	Concentrate leftovers (g)							
	Rectal Temperature (morning feeding)							

Attachment 2



Calf Colostrum feeding project

Calf colostrum feeding via Oesophageal Tube (OT), suckling or bottle

Faeces scoring system:

Health records: If any health problem arises please inform Carlos or Bengt-Ove about it and record it in the health sheets provided.

During the whole experimental period, farm staff is requested to record any health issues with the calves, any treatment (given by vet or by farm staff) and record faeces consistency in case of diarrhoea in the sheet provided for each calf according to the scores below

<u>For calves in tie stall: record faeces score daily during morning feeding for all calves.</u>

Faeces score:

Score: 0 = Normal faeces. Firm consistency. Brown colour. Clean and dry tail and perineum

Score: 1 = Faeces with a paste-like consistency without shape. Yellow colour

Score: 2 = Watery consistency

Score: 3 = Watery consistency with blood

Note that: Perineum and/or tail are smeared with faeces at score 1 and 2 and 3. Runny to watery stools with blood are considered diarrheic. Grading 1-3 are by definition diarrhoea and grade 2 and 3 are considered as severe diarrhoea.