Feeding of dry cows
– a good start on the lactation

Utfodring av sinkor – en god start på laktationen

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Master's Thesis • 30 credits
Swedish University of Agricultural Sciences, SLU
Department of Animal Nutrition and Management
Agricultural Science programme – Animal Science
Uppsala 2020

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Credits:	30 credits
Level:	Advanced
Course title:	Independent project in Animal Science, A2E
Course code:	EX0872
Programme/education:	Agricultural Science programme – Animal Science
Place of publication:	Uppsala
Year of publication:	2020

Keywords: Total mixed ration, separate feeding, one day feeding control, close-up, far-off

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Abstract

At parturition, it is a critical period and an increased risk of the cow being affected by metabolic diseases. The dry period is therefore a preparation for both parturition and the coming lactation. Today's feeding recommendations for dry cows are debated and advisors express that a clearer guideline is needed. A large focus is on the lactating cows and the dry cows are at risk of falling into the cloud. This master thesis has compared total mixed ration and separate feeding and studied its effect on body condition score and urine pH during the dry period and the energy balance before calving. Management for dry cows and feed ration composition has also been studied. The thesis is based on a field study in which 20 farms in Sweden have participated. For two months, farmers have documented information related to calving. One visit had been made at each farm where assessment of body condition score, urine sampling and tour with the purpose of documenting has been carried out. Farmers also had to answer a number of questions about the dry cows. In addition, feed analyzes, and water analyzes has been performed on taken samples. The results showed that using total mixed ration or separate feeding had no effect on the parameters studied. The feed rations of the dry cows comply with the recommendations in general, but the parameters energy balance and cation-anion balance showed large deviations from the recommended values. The study also showed that farmers management around dry cows differs in many areas.

Keywords: Total mixed ration, Separate feeding, one day feeding control, close-up, far-off

Sammanfattning

Perioden kring kalvning är kritisk och det medför en ökad risk för kon att drabbas av metaboliska sjukdomar. Sinperioden är därför en förberedelse för både kalvning och kommande laktation. Dagens foderstatsrekommendationer till sinkor är omdiskuterade och rådgivare efterlyser tydligare riktlinjer. Ett stort fokus riktas mot de lakterande korna och sinkorna riskerar att hamna i skymundan. Det här examensarbetet jämförde fullfoder och separat utfodring och studerade dess påverkan på hull och urin pH under sinperioden samt energibalansen innan kalvning. Skötselrutiner kring sinkor och foderstaters sammansättning studerades också. Arbetet baserades på en fältstudie på 20 svenska gårdar i Sverige. Under två månader dokumenterade lantbrukarna information i samband med kalvningar. Ett besök gjordes på varje gård där bedömning av hull, urinprovstagning och rundvandring gjordes. Lantbrukarna fick också besvara ett antal frågor kring sinkorna. Utöver detta utfördes foderanalyser och vattenanalyser på uttagna prov. Resultatet visade att fullfoder och separat utfodring inte hade någon effekt på de undersökta parametrarna. Sinkornas foderstater följde rekommendationerna i stor utsträckning men parametrarna energibalans och katjon-anjon balansen visade sig svåra att uppfylla enligt de nuvarande rekommendationerna. Studien visade också att lantbrukarnas skötselrutiner kring sinkorna skiljer sig mycket.

Nyckelord: Fullfoder, Separat utfodring, endagars utfodringskontroll, close-up, far-off

Acknowledgements

First, I would like to thank, my supervisors Cecilia Kronqvist, Maria Åkerlind and Ann-Theres Persson for all help and support with this thesis.

I would also like to thank Ebba Kajlöv, Carlos Hernandez, Ann-Catrin Markusson and Anders H. Gustafsson which were a part of this project as well.

Thanks to Sofi Öhlund, Emelie Uggla and Nilla Henning for the help with feed and water analyses.

Last but not least, a big thank you to all the farmers who participated in this project.

The project was financed by the foundation Seydlitz MP-bolagen, without that, the project could not have been completed, thank you very much.
I also want to thank Östads stiftelse for the scholarship.

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Abbreviations

BHB	β-hydroxybutyrate
Ca	Calcium
CAD	Cation anion difference
Cl	Chloride
Co	Cobalt
Cu	Copper
DIM	Days in milk
DM	Dry matter
DMI	Dry matter intake
F	Fluoride
Fe	Iron
FV	Iodine
I	Filled value
K	Potassium
ME	Metabolizable energy
mEq	Milliequivalents
Mn	Manganese
Mg	Magnesium
Na	Sodium
NDF	Neutral detergent fiber
NE	Net energy
NEFA	Nonesterified fatty acids
P	Phosphorus
PBV	Protein balance in rumen
S	Sulphur
Se	Selenium
Si	Silicon
TMR	Total mixed ration
Zn	Zinc

1. Introduction

The dry period prepares the cow for the forthcoming lactation and the importance of feeding during this period for milk production and health are well known (Kronqvist *et al*., 2012; Dunn *et al*., 2017). There is a critical period around parturition when it is an increased risk that the cow will be affected by metabolic diseases like milk fever and ketosis (Goff & Horst, 1997a). Feed intake during the first part of lactation is crucial for the cow to manage negative energy balance in the best way and for milk production not to be reduced too much. Generally, cows get into negative energy balance after calving but how severe it is varies (Garnsworthy, 2007). A negative energy balance occurs because more energy is used for milk production compared to how much energy that is received from the feed intake. Altogether this could affect the forthcoming lactation (Agenäs *et al*., 2003; Dann *et al*., 2006) and in the long run affect the welfare of animals and farmers economy due to diseases and lower milk production.

Dry period can be divided into two periods regarding feeding; far-off and close-up (Dann *et al*., 2006). The close-up period is often the three last weeks before expected calving. In some farms, same feed is given during the whole dry period. Recommendations and procedures about dry cow feeding differ and research results are inconsistent (Mann *et al*., 2015). For example, if a far-off/close-up strategy or the same ration over the entire dry period should be applied. Even advisors in Sweden think recommendations are inconsistent about the feeding strategies and especially if cows are fed with total mixed ration (TMR) or separate feeding. For separate feeding, forage and concentrate are fed separately while for TMR it is fed together in the ration. Dry cows do not need as nutritional feed as lactating cows, but the question is if today's recommendations are correct in relation to reality and advisors wants a more clearer guidance. This is one of the main reasons behind this project. Another aspect is that some farmers experience that both quality and amount of colostrum is low after calving. This issue is part of the project but highlighted in another master thesis (Kajlöv, *in press*). In addition, studies about dry cows and their feeding are less common today compared with the number of studies about lactating cows.

The aim of this study was to compare TMR and separate feeding during the dry period and see how it affected body condition in the dry period, energy balance and urine pH before calving of the dry cows. Management of dry cows was also studied. The proportion of animals showing high levels of BHB in milk after calving and the presence of milk fever was compared between farms. Data from twenty farms located in Sweden were used for this observational study.

2. Literature review

Dry period can be divided into a far-off and a close-up period where the feeding strategy can be different during these periods. First four to six weeks are the far-off period and last three weeks the close-up period (Dann *et al*., 2006). An alternative is to feed the same diet during the whole dry period. Having a dry cow diet that has same components as the dairy cow diet but diluting it with low energy forage or straw, can prepare the cow for the diet given after calving (Drackley & Guretzky, 2007). Concentrations of nonesterified fatty acids (NEFA) and β-hydroxybutyrate (BHB) in blood are useful as it may be an estimation of energy balance (Dann *et al*., 2006; Mann *et al*., 2015). The study by Dann *et al*. (2006) investigated the effects of far-off and close-up diets on prepartum and postpartum metabolism. They concluded that far-off feeding affected the metabolism, close-up feeding did not. The results showed that overfeeding (150 % of NRC (2001) net energy recommendations) during far-off period leads to higher concentrations of blood BHB prepartum as well as an increase in body weight, no matter what diet they were given during close-up period. Postpartum, far-off diets had an effect on the metabolism, cows with a restricted diet had lower NEFA and BHB concentrations in blood and higher energy balance 10 days in milk (DIM) compared to cows given 150 % of NE recommendations. The diets during close-up period did not show any major effect on metabolism postpartum but had an effect prepartum. Concentrations of NEFA in blood prepartum were lower when cows were fed ad libitum than when given a restricted diet during close-up period.

Another study concludes instead that a high fiber diet over the entire dry period which met the recommendations gave the cow a gentle transition to lactation (Mann *et al*., 2015). The dry cows were given one of three TMR diets. The different diets were; a controlled high fiber diet (484 g NDF/kg DM) that met their energy requirements, a high-energy diet which supply 150 % of energy demands (410 g NDF/kg DM) and the last group got the controlled diet during far-off period and during close-up period a diet that supply 125 % of energy requirements (422 g NDF/kg DM). The high energy diet gave elevated values of both NEFA and BHB in blood after calving, which might indicate a negative energy balance. These cows also had an increased incidence of hyperketonemia. Therefore, their conclusion was that the high fiber diet was the one that best prepared dry cows for parturition.

Dry matter intake (DMI) after calving is important for milk production in the first part of lactation. Dry cows that were fed a lower energy diet (5.4 MJ net energy (NE)/kg DM) during the far-off period had a higher DMI after calving compared to if they were overfed (6.7 MJ NE/kg DM) (Dann *et al*., 2006). The diet during close-up period showed no effect on DMI after calving. The study by Mann *et al*. (2015), however, showed no difference in DMI postpartum when the dry cows received diets with different energy content. The effect on DMI postpartum was investigated depending on what body weight the cows had at parturition (Agenäs *et al*., 2003). Therefore, dry cows were given different amounts of the same TMR (11.8 MJ metabolizable energy (ME)/kg DM) which were 6, 9 and 14.5 kg DM per day during 8 weeks before expected calving. The diets were described as low, medium and high dry period rations to provide different amount of energy per day. Rations had no effect on the first weeks of lactation. However, DMI was lower between week six to twelve postpartum for the high ration group compared to the restrictively fed groups medium and low. The high ration cows had highest body weight and body condition at parturition.

2.1. Feed composition during the dry period

Dry cows do not need a high energy diet like lactating cows as they do not produce milk. Instead they can be fed with a diet that contains a large amount of forage and is higher in neutral detergent fiber (NDF) (Goff & Horst, 1997a). A high proportion of NDF in the feed ration is advantageous during the dry period for the cow's satiety. It also provides a good possibility for cow's mobilization of lipid reserves to start in early lactation (Friggens *et al*., 2004). However, it is important that mobilization starts in a gentle way as the dry cows must not get too fat. The energy supply, in relation to requirement, at parturition is recommended to 100 % (Nielsen & Volden, 2011). During the first part of the lactation, the energy allocation can be below 100 % as energy is mobilized from body reserves. Therefore, it is recommended that the energy supply should be more than 100% in mid lactation for body stores to be replenished. Recommended amount of net energy (NE) for a dry cow in gestation day 270 with a body weight of 700 kg is 60.3 MJ per day. For NDF, it is recommended that 40-50 % of total DM is forage NDF (Drackley & Guretzky, 2007). Växa Sverige (2017) recommends for NDF > 500 and > 350 g/kg DM in far-off and close-up periods, respectively. Total protein balance in rumen (PBV_N) for dry cows is recommended to 10-40 g/kg DM (Nielsen & Volden, 2011). The requirement of amino acids absorbed in the small intestine (AAT_N) for pregnancy increases the further into the gestation the cows come. In the last three weeks before calving, the recommended extra intake is about 286 g AAT_N per day. The maintenance is based on DMI and are here calculated for 12 kg

DM/day and are about 280 g per day. Therefore, the requirement is about 566 g AAT_N per day. Recommendations are presented in table 1.

Cation anion difference (CAD) is useful when calculating the diet for dry cows to prevent milk fever (Sjaastad *et al.*, 2010). CAD is calculated by the equation $(\left(\frac{K}{39,1}+\frac{Na}{23,0}\right)-\left(\frac{Cl}{35,5}+\frac{S\times 2}{32,0}\right))\times 1000$ and the unit is milliequivalents (mEq) (Volden, 2011). Nielsen & Volden (2011) recommends a negative CAD of -150 to 0 mEq/kg DM during dry period, especially last 3-4 weeks before calving. Lopera *et al.* (2018) showed that dietary CAD of -70 mEq per kg DM during prepartum was more favorable for urine pH (6.5) compared to -180 mEq/kg DM (pH 5.5). Also, the duration of low CAD had impact, where short period of 3 weeks before calving compared to 7 weeks resulted in higher DMI and higher milk yield postpartum.

The recommended intake of vitamin E is 1.6 IU/kg BW, vitamin D and A are 30 and 110 IU/kg BW, respectively (Nielsen & Volden, 2011). Vitamin D is needed for animals to be able to utilize calcium effectively (Suttle, 2010). Vitamin E and selenium (Se) interact and lack of these can result in tissue and cell damage in many organs (Sjaastad *et al.*, 2010). Transport of vitamin E via the placenta is poor. Therefore, the content of vitamin E in the ration during dry period could be of importance as the calf receives it from the colostrum (Quigley & Drewry, 1997). The review by Quigley & Drewry (1997) found that the research is inconsistent about whether the feed's content of vitamin E affects the vitamin E content in colostrum. Vitamin A is involved in the visual function, among other things, where deficiency can lead to night blindness (Sjaastad *et al.*, 2010).

2.1.1. Minerals

Minerals play an important role during dry period. Calcium (Ca) is important for muscle contractions and skeletal function (Wilde, 2006). Regulation of Ca is controlled by the hormones 1,25-dihydroxyvitamin D and parathyroid hormone. Almost all Ca found in the body is presented in bone tissue (Sjaastad *et al.*, 2010). Calcium is also needed for milk synthesis. During dry period, physiological systems of the cow should be prepared for Ca mobilization and absorption (Friggens *et al.*, 2004). When the cow starts to produce colostrum, Ca is required and this may involve a risk of hypocalcemia because the cow may have difficulty compensating for the Ca loss (Zimpel *et al.*, 2018). One to two days prepartum the colostrum production begins (Friggens *et al.*, 2004). A lower amount of Ca in the feeding ration is recommended during dry period in order for the cow to better mobilize and absorb Ca at parturition. The meta-analysis by Lean *et al.* (2006) found that lower and higher amounts of dietary Ca (% of DM) lowered incidence of milk fever. Calcium concentrations of 1.1 to 1.5 % of DM showed the highest incidence of milk fever and the meta-analysis then recommends a ration of < 1.1 to > 1.5% of DM during dry period. Content of Ca in the feeding ration can therefore be a way to prevent milk fever.

Normal magnesium (Mg) levels are maintained as long as Mg is available from the diet (Goff, 2008). Magnesium affects many functions in the body because it is included in a lot of enzymes (Schonewille, 2013). These enzymes are involved in functions such as protein synthesis, energy metabolism and cell growth. Lack of Mg can lead to hypocalcemia but also grass tetany. In a meta-analysis, Lean *et al*. (2006) found that adding Mg to the diet can reduce risk of hypocalcemia, which the study by Kronqvist *et al*. (2012) also support where different amounts of Mg were fed to dry cows. The lowest amount Mg, 12-25 g per day, was associated with an increased risk of hypocalcemia. This range of Mg cover the recommendation presented in Table 1. Goff (2008) recommends an amount of Mg between 3.5-4 g/kg DM during close-up period so that Mg absorption should not be impaired.

Phosphorus (P) also have an important function for structure in tissues, muscles and organs (Suttle, 2010). The mineral also being a part of regulating proteins and nucleic acids through transcription and translation. During early dry period, it is recommended a moderate overfeeding of P because a sufficient skeleton reserve should be present before and after parturition. Deficiency can lead to impaired bone mineralization and abnormal appetite (Sjaastad *et al*., 2010). This can be shown by the fact that animals eating bones, soil and even tissues from dead animals. Too much P (> 80 g P/day) in the diet is not recommended as it may adversely impair the production of 1,25-dihydroxyvitamin D and thus the incidence of hypocalcemia (Goff, 2008). 1,25-dihydroxyvitamin D is a hormone that affects the efficiency of absorption of Ca in the gut. Recommendations of the intake of minerals for a dry cow with body weight at 700 kg are presented in Table 1.

Table 1. Feed requirements for dry cows. NE recommendation is for a dry cow in gestation day 270 with a body weight of 700 kg.

Parameter	Requirements
NE	60.3 MJ/day[1]
NDF	> 350 g/kg DM[2]
PBV_N	10-40 g/kg DM[1]
AAT_N	566 g/day[1]
Minerals	**Minimum intake**
Ca	35.3 g/day[1]
P	24.1 g/day[1]
Mg	15.2 g/day[1]
K	5.2 g/kg DM[3]
Na	1 g/kg DM[3]
S	2 g/kg DM[3]
Fe	13 mg/kg DM[3]
Mn	18 mg/kg DM[3]
Zn	22 mg/kg DM[3]
Cu	13 mg/kg DM[3]
Co	0,11 mg/kg DM[3]
Se	0,2 mg/kg DM[3]
I	1,0 mg/day[1]

[1]Nielsen & Volden (2011)

[2]Växa Sverige (2017)

[3]Spörndly (2003)

2.2. Water intake

Cows need a high amount of water and receives it from three sources; from the body's metabolism of nutrients, by free water intake and from the water contained in feed (NRC, 2001). Usually, consumption of free water is between 3.5-5.5 kg/kg DM (NRC, 1988). There are no uniform guidelines to follow regarding water quality for animals, the only thing is that they should have free access to water (Spörndly, 2003). There are different opinions about water quality where some says that animals should have specific quality criteria for water (Jordbruksverket, 1999) and another that it should be same criteria's as for humans (SLVFS 2001:30; Appendix 6).

2.3. Risk of diseases related to feed

Around parturition it is a critical period and an increased risk that the cow will be affected by different diseases. Risk of diseases can be affected by feeding, in this case related to the dry period. For example, overfeeding during dry period can lead to health problems like hyperketonemia and fatty liver, and also make the transition to lactation period more difficult (Drackley & Guretzky, 2007).

2.3.1. Body condition score

Body condition scoring is a tool for monitoring the nutritional status of cows, both lactating and dry cows, as it is affected by both energy balance and energy intake (Garnsworthy, 2007). DMI can be adversely affected postpartum if body condition is too high at parturition, which means that energy intake during dry period should not result in weight gain for the cows. It is optimal that when cows are dried off, they should have a body condition that is desirable at parturition so that they neither lose nor gain weight during dry period. Cows with higher body condition score have been shown to have a lower DMI and also lower milk yield in early lactation (Garnsworthy & Topps, 1982). Common diseases that may be affected by body condition at parturition are milk fever, fatty liver and ketosis (Roche *et al*., 2013). The recommendations regarding body condition around calving vary between studies and is usually estimated on a scale of 1-5. The article by Garnsworthy (2007) describes that body condition should be around 2.75-3.0. Advisors at Växa Sverige recommends that body condition should be 3.25 for Holstein and 3.5 for Swedish red (SRB) at parturition. While others recommend scores at 3.0-3.25 (Roche *et al*., 2009; Roche *et al*., 2013). The recommendations are based on the fact that risk of metabolic diseases is increased at a higher body condition score. On the other hand, the cows should not be too thin as it can cause problems all over lactation and around calving like severe negative energy balance and reduced DMI (Roche *et al*., 2013).

2.3.2. Energy balance and hyperketonemia

A diet high in energy can lead to an excessive body condition at calving, which increases risk of complications around calving and can result in negative energy balance being more severe postpartum (Garnsworthy, 2007). Cows end up in a negative energy balance postpartum because more energy is used for milk production compared to how much energy they get from the feed intake (Dann *et al*., 2006). When cows get into a negative energy balance, the risk of hyperketonemia also increases, which means that ketone bodies in the blood rises (Herdt, 2000). When developing hyperketonemia, energy metabolism is disturbed and it can adversely affect milk production and, in the worst case, result in displaced abomasum (Duffield *et al*., 2009). In the study, the risk of hyperketonemia increased at a threshold value of BHBA ≥ 1.2 mmol/l blood and the risk of displaced abomasum also increased with elevated BHBA concentrations. The authors mention that there are similarities between the two diseases due to that they may have similar causal etiologic pathways for the factors causing greater levels of ketones, and that it may be an explanation for the linking between the two diseases. A controlled diet with an energy content that meets the requirement reduces risk for hyperketonemia compared with a high energy diet (Mann *et al*., 2015). The incidence of hyperketonemia increased both with an overfed cow throughout the whole dry period but also when dry period was divided into a far-off and a close-up period. The diets were then a controlled energy-diet during far-off period and a diet that corresponded 125 % of the energy requirement during close-up period.

Cows that were overfed during the dry period have also been found to lose more body weight after calving, which may indicate that they have ended up in a more severe negative energy balance, and NEFA concentrations were higher in these cows as well (Rukkwamsuk *et al*., 1998). The study by Agenäs *et al*. (2003) also evinced body weight loss postpartum where the group fed with the highest energy supply (14 kg DM of 11.8 MJ ME/kg DM) had the greater decrease than those fed medium and low energy level (9 and 6 kg DM). First week after parturition all groups had a loss due to calving but then the group fed high energy level during the dry period continued to lose body weight until third week postpartum.

2.3.3. Fatty liver

Adipose tissue is important as it supplies organs with energy in form of fatty acids (Rukkwamsuk *et al*., 1998). According to Goff & Horst (1997a) there is a limit for how much fatty acids that can be oxidized from the adipose tissue. This limit is often reached postpartum because the cow gets into negative energy balance and needs to utilize energy from body fat. What then occurs is that the liver's capacity to form lipoproteins is impaired because it is exceeded by mobilization of fatty acids and triglycerides are accumulated in the liver (Sjaastad *et al*., 2010). When these triglycerides accumulate in the liver, liver function is negatively affected, in turn the body is affected by the disease fatty liver. The study by Rukkwamsuk *et al*. (1998) showed higher concentrations of fatty acids released from the adipose tissue when cows were overfed during the whole dry period, and that in turn resulted in greater amounts of fatty acids that accumulate which indicates a more severe fatty liver postpartum.

2.3.4. Hypocalcemia

In Sweden, in 2018/2019, 2 % of the dairy cows were treated for milk fever (Växa Sverige, 2019). The risk increases from second lactation (Sjaastad *et al*., 2010). What happens when hypocalcemia occurs is that Ca supply is lower from the diet or from the skeleton compared to the uptake into the mammary glands for milk production (Wilde, 2006). Why multiparous cows are at greater risk of being affected is because they do not have sufficiently available Ca reserves in the bone (Sjaastad *et al*., 2010). During last stage of dry period, a diet resulting in a Ca balance that is negative, can prevent hypocalcemia. This is positive since bone resorption and absorption of Ca are activated and prepared before parturition. It has been found that diets with high amounts of cations, especially Na and K, have increased risk of milk fever (Block, 1984). These cations increase CAD that causes an increased sensitivity to milk fever. In one study, different additions of Ca and K were compared, high and low, to see the incidence of milk fever (Goff & Horst, 1997b). Different amounts of Ca (0,5 and 1,5 % of the diet) gave no significant difference in the incidence of milk fever. Increase of K from 1.1% to 2.1 or 3.1% in the diet (on DM basis) had an effect as more cases of milk fever were developed (2 of 20 cows, 10 of 20 cows and 11 of 23 cows respectively).

Hypocalcemia can be prevented by feeding anionic salts to dry cows as it may result in a metabolic acidosis which can reduce the risk of the disease (Zimpel *et al*., 2018). A diet with 3.1% K gave a higher urine pH compared to a diet containing 1.1% K (Goff & Horst, 1997b). Urine pH was over 8.0 with the diet highest in K and 5,75 for the diet with 1,1 % K. This means that diets with a high proportion of cations can result in an alkaline urine pH (Seifi *et al*., 2004). The study by Zimpel *et al*. (2018) supports this where urine pH decreased the more anions that were added to the feed. Dry cows given a diet with negative dietary CAD (-114 mEq/kg DM) were the ones with the lowest pH values, 5.5-5.6. By measuring urine pH over the last three weeks before calving the effectiveness of the feed including anionic salts can be controlled (Santos *et al*., 2018). Urine pH will optimally be around 5.5-6.5 if the anionic salts are consumed, which depending on the dietary CAD value.

2.4. Dry period length

Today, it is most common for dairy cows to have a dry period length of 8 weeks. It is investigated whether 8 weeks is the most optimal length and, for example, how it affects production and health if dry period would either be longer or shorter. A study investigated whether metabolic changes were affected by a dry period of 28, 56 and 90 days, respectively (Weber, *et al*., 2015). Three groups were fed with TMR ad libitum with a far-off and a close-up ration. The 28-day group was fed only with the close-up ration. Concentrations of NEFA and BHB in blood were increased at parturition for all groups but the increase was greatest in the 90-day group. A shorter dry period, 28 days, gave no difference in NEFA and BHB concentrations compared to 56 days dry period. The milk yield increased for all groups postpartum but declined after 6 weeks for the 28- and 56 days group. For the 90-day group the milk yield continued to increase until week eight. The study by Andrée O'Hara *et al*. (2019) compared a dry period of 56 days against a shorter one of 28 days. Postpartum, it showed no difference for BHB concentrations in blood between the treatments but NEFA concentrations was higher for the 56 days group and it could be related to less severe negative energy balance for short dry period cows. Based on findings of Andrée O'Hara *et al*. (2019), Nordic recommendations of dry period length has changed from 8-9 weeks to 7-8 weeks (Växa Sverige, 2020a).

3. Materials and Methods

3.1. Data

Data were collected at twenty farms located in different areas in Sweden, mainly in Halland and Dalarna. Farms were selected by advisors at Växa Sverige based on feeding strategy, TMR and separate, for lactating cows at the farms. In total 28 farms were contacted which had at least 50 cows and which were considered orderly as well as those who could be assumed to have an interest in participating. After all, one participating farm had less than 50 cows. The idea was to have five TMR farms and five separate feeding farms in each region. Some farms declined and because of this, farms outside the regions were contacted and feeding strategies were not evenly distributed. The reasons why farms declined was because of staff shortage, adjustments among the staff and lack of time. They also mentioned that they did not want to undertake a task they could not complete.

The participating farms were eight farms in Halland, two farms in Småland, eight farms in Dalarna, one farm in Västmanland and one farm in Södermanland. The dry cows at these farms were fed by TMR or separate feeding. Data were collected during farm visits on each farm and farmers documented the calvings for two months. Information about farms were also received from Swedish milk recording scheme and DelPro. DelPro is a platform established by DeLaval where farmers can enter and collect information about the farm which is then presented by DelPro. Swedish milk recording scheme is a platform managed by Växa Sverige where farmers report information into. Farms are presented in table 2.

Table 2. Presentation of farms

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

[1] Change to TMR about three weeks before calving

3.2. Farmers documentation

During the time period 2020-01-20 to 2020-03-20 the farmers were documenting information related to calvings. They documented if cows been treated during the time period and if cows were given supplement during dry period. Length of dry period was also written down. BHB-value and health statistics was retrieved from the Swedish milk recording scheme. Data used in the joint project is presented by Kajlöv (in press). Two different forms were used for calf and cow documentation by farmers and can be found in (Appendix 1). Additional information about forms for the documentation were available (Appendix 2). Data were then compiled when the time period was over.

3.3. Farm visits

Before visits some practicing was done at Swedish Livestock Research Centre at Lövsta, Uppsala, for example urine sampling, measuring colostrum and weighing calves. This was done in order to be prepared for questions that could arise for farmers and to be ready for farm visits. One visit at each farm was done during a period from 2020-01-29 to 2020-03-10.

Body condition of ten dry cows was scored at each farm using the form by Gillund *et al*. (1999) (Appendix 3). Dry cows were randomly selected. The score was a scale from 1-5. Also, urine samples were taken from these dry cows. Some farms had fewer than ten dry cows at the visit and measurements were then done for as many as they were. The pH-value were measured for the urine samples with a pH meter (Mettler Toledo) firstly but at some farms with a pH paper because the electrode at the pH meter broke and was replaced with a new. Measurement range for pH meter was pH 0-14 with limits of error at ±0.01 (Mettler Toledo). pH paper had a scale from pH 6.4-8 (Merck). Urine samples were measured immediately after collection. At some farms weight was estimated of the dry cows with a measuring tape. Measuring tape range was for the animals living weight (30-880 kg) in relation to breast size (0-223 cm). Body weight (kg) can be estimated by this function; $Y = 129{,}9 – 3{,}251x + 0{,}02775x^2$ where X is chest circumstance in cm (Coburn, 2000). Housing of calves, dry cows and pregnant heifers were documented. Farmers got to answer some additional questions about management, housing and feeding for the earlier mentioned groups. Form for documentation at farms can be found in (Appendix 4).

3.4. Feed intake and sampling

Feed intake was measured once at each farm, a so called one-day feeding control. The total amount of feed which the group of dry cows were fed for one day was weighed and then leftovers were weighed 24 hours later. Leftovers were weighed by us or by the farmer. Number of animals was counted to know how many cows had eaten from the feed. All data were then entered into the computer tool IndividRAM (Växa Sverige) using NorFor feed evaluation system (FST revision 2.03, FRC revision 1.98 and OFC revision 1.31, NorFor amba) for calculations. At farms with far-off and close-up feeding, two one day feeding controls were done.

Feed samples were taken by advisors at Växa Sverige and drinking water was sampled where dry cows drank and sent to lab. Table values were used for feeds where analyses were missing. Those table values were taken from Norfor feed table (Norfor, 2020). Mineral values in commercial concentrates and mineral mixtures were according to product information from the selling feed companies. In some cases, feed companies were contacted for complete mineral composition.

Samples were taken on TMR and silages for measuring the current DM since DM of silage can vary in the silo. They were taken at the same time as the one-day feeding control was performed. Samples were taken in plastic gloves or three- or five-liters plastic bags and were taken from the dry cows feeding table and silages were taken in bunker silos, round bales and tubes. If DM results from the samples was different from the results of feed analysis from the commercial lab, the value was changed manually in IndividRAM.

3.5. Analyses on feed and water

For nutritional analysis, water and feed samples were taken by advisors at Växa Sverige. The feeds were analyzed by Eurofins Agro Testing Sweden AB and water was analyzed by the Chemical Analysis Laboratory at Swedish University of Agricultural Science (SLU). In addition, wet feed were sampled during the visit at each farm and analyzed for DM.

3.5.1. Water

At SLU drinking water were analyzed for the minerals Ca, Mg, K, Na and silicon (Si) according to SS-EN ISO 17294-2:2016 and also with chloride (Cl), sulphate (SO_4) and fluorine (F) according to SS-EN ISO 10 304-1:2009 (Swedish Standards institute 2009; Swedish Standards institute 2016). Total water intake was assumed to be 4.5 L/kg DMI according to Spörndly (2003). Drinking water intake was estimated to be total water intake adjusted for water from feed. The CAD from drinking water was added to the dietary CAD.

3.5.2. Silage

At Eurofins samples of grass-clover silage and whole crop silage were analyzed for organic matter digestibility (OMD), crude protein (CP), soluble crude protein (sCP), ammonia nitrogen (NH_3N), crude fat (Cfat), NDF, starch (ST), water soluble carbohydrates (WSC) and Cl with Near-InfraRed Spectroscopy (NIRS) (Eurofins, n.d.). The feed samples were dried in 60 degrees for measuring the DM according to Åkerlind *et al*. (2011) and ashed according to EU (2009). Ten minerals, Ca, P, Mg, K, Na, sulphur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), were analyzed with inductively coupled plasma-atomic emission spectrometry (ICP-AES) (Mindak & Dolan 2010).

3.5.3. Straw

Straw was analyzed for CP, crude fibre and Cl with NIRS (Eurofins, n.d.). The samples were dried and ashed like the silage samples above (EU, 2009; Åkerlind *et al.*, 2011). NDF was analyzed according to ISO 16472:2006 IDT. The minerals, Ca, P, Mg, K, Na, S, Fe, Mn, Zn, Cu, were analyzed with ICP-AES (Mindak & Dolan 2010).

3.5.4. Grain

Grain samples were also ashed and dried like the other feed samples (EU, 2009; Åkerlind *et al*., 2011). Crude protein was analyzed according to EN ISO 5983-2 (European Committee for Standardization, 2005). Crude fat was analyzed with the method ISO 6492:1999 (International Organization for Standardization, 1999) and starch with SS-EN ISO 15914:2006 (Swedish Standards institute, 2006). ICP-AES was used for analyzing the minerals, Ca, P, Mg, K, Na, S, Fe, Mn, Zn, Cu (Mindak & Dolan 2010).

3.5.5. Silage and TMR at farm visits

Samples of DM were weighed, dried in an owen, weighed again and then DM was calculated. Starting weight was not consistently the same weight for all samples but in the interval 50-500 g. Temperature for the owen was 70 degrees in Halland and samples was dried overnight. In Dalarna and Småland, temperature was 80 and 65 degrees, respectively. Samples in Västmanland and Södermanland was frozen down and then dried in Halland and Dalarna respectively. DM was calculated by dividing the weight after drying by the weight before drying.

3.6. Statistical analyses

JMP Pro 15.0.0 was used for statistical analyses. All raw data was entered in Microsoft Excel 16.30 and then imported into JMP. The effect of feeding strategy on the different parameters in feed was analyzed with the parameters as a dependent variable and feeding strategy as a fix factor. T-test was used for comparison, mean values and standard errors were calculated. One T-test was done for each parameter. The analyzed feed parameters were net energy intake, energy balance, PBV, NDF, Ca intake, P intake, Mg intake, K, Na, S, Fe, Mn, Zn, Cu and CAD. The effect of feeding strategy on urine pH was analyzed using standard least squares means with feeding strategy as a fix factor, CAD as a co-factor and farm ID as a random effect. The effect of feeding strategy on body condition score was analyzed with a non-parametric test, body condition score as a dependent variable and feeding strategy as a fix factor. Mean values and standard errors were calculated. Graphs were created in Excel. Means, minimum and maximum were calculated by using Excel for feed parameters, water analyses, BHB and dry period length.

4. Results

In total, data about 578 cows were collected in this study. The number of documented calvings are presented in table 3, column 2. Between two and ten dry cows were assessed on each farm. The proportion of assessed animals of the total number of dry cows at the farm visit is also presented in table 3, column 3. The variation in documented calvings is within a range from five to 66.

Table 3. Number of documented calvings during two months and the percentage of assessed dry cows at the farm visit for both BCS and urine pH.

Farm number	Documented calvings	No. of dry cows at visit	BCS	Urine pH
Farm 1	13	7	100 %	86 %
Farm 2	7	3	100 %	67 %
Farm 3	45	31	32 %	29 %
Farm 4	34	23	43 %	30 %
Farm 5	35	46	17 %	10 %
Farm 6	15	81	12 %	11 %
Farm 7	15	13	46 %	38 %
Farm 8	15	4	100 %	75 %
Farm 9	52	90	14 %	11 %
Farm 10	23	18	44 %	39 %
Farm 11	49	42	36 %	32 %
Farm 12	12	14	57 %	50 %
Farm 13	66	19	47 %	47 %
Farm 14	46	27	59 %	41 %
Farm 15	13	5	100 %	100 %
Farm 16	45	35	45 %	45 %
Farm 17	5	6	100 %	83 %
Farm 18	56	56	27 %	27 %
Farm 19	14	6	100 %	83 %
Farm 20	18	7	100 %	57 %

4.1. Management

The division between TMR and separate feeding was eight and ten farms respectively. Two farms had two different feeding strategies during dry period, separate feeding during far-off and TMR during close up. In total, 14 farms used the far-off/close-up strategy and six applied the same feed throughout the dry period. Three farms moved the dry cows into the lactating cows barn the last weeks before calving. All but two farms provided dry cow minerals to their dry cows. The dry cows at these two farms got ordinary minerals for lactating cows. Eighteen farms used preventative treatment for milk fever. Which cows that were treated varied between farms, but most used treatment for the multiparous cows on routine. The treatments used were Bovikalc, After calving (Mosegarden A/S), phosphate paste, calcium paste and X-Zelit. The two farms that did not used preventive treatment did not had noticeably less or more milk fever in 2019 compared to the others which treated.

Nineteen of twenty farms used dry cow treatment at drying off. Here it was very different which cows that the farmers chose to treat. Most treated cows with high cell counts. Many chose after udder health class. Other parameters they chose for were: if necessary, high producing or after veterinarian recommendations. The housing of the dry cows was either loose housing, kept in tie-stalls or in deep straw bedding but it could not be linked to what feed strategy they chose to use. Some farms kept their pregnant heifers with the dry cows the last month before calving. Most farms used a feeding wagon when feeding, but some smaller farms fed manually or with a smaller loader.

4.2. One day feeding control

A total of 29 one day feeding controls were calculated in IndividRAM. The animal groups ranged from two to seventy dry cows. For the farms that applied the far-off/close-up strategy, calculations for both periods were made except from three farms. The reason for this was that on two farms the dry cows were moved to the lactating cows barn and at the visit there was no or only one dry cow in the close-up group. Therefore, no one day feeding control was performed for the close-up group on those farms. On the third farm, the far-off group was not fed during the farm visit, which meant that the one day feeding control was done for the close-up group only. Mean-, minimum- and maximum values from the one day feeding controls can be found in Appendix 5.

Six feed rations did not meet the recommendations for PBV which is 10-40 g/kg DM where three rations were lower and three were above the recommended amount. All rations were >350 g/kg DM in NDF which was recommended for the close-up period. During the far-off period, the NDF should be >500 g/kg DM and five far-off rations had a value below this.

There was no difference between the feeding strategies in any of the measured feed variables, p > 0,10. Mean values and standard errors for close-up rations can be found in table 4. Values from farm 1 and 2 was excluded in this calculation because values are available only for far-off rations.

Table 4. Feed intake and diet composition to dry cows from twenty Swedish farms, close-up rations

Parameter	**TMR Mean ± Std Err**	**Separate Mean ± Std Err**	**p-value**
DMI, kg DM/day	14,7 ± 1,05	14,7 ± 2,08	0,50
Fill value, %[1]	103,1 ± 7,4	108,2 ± 16,2	0,39
Net energy intake, MJ/day	84.9 ± 7.3	89.6 ± 11.0	0,36
Energy balance, %[2]	152 ± 13	159 ± 19	0,39
PBV, g/kg DM	21 ± 3	27 ± 6	0,20
NDF, g/kg DM	446 ± 21	436 ± 20	0,63
Ca intake, g/day	88.5 ± 13.8	99.8 ± 10.1	0,26
P intake, g/day	53.1 ± 4.7	49.8 ± 7.2	0,65
Mg intake, g/day	58 ± 5.6	49.3 ± 8.2	0,80
K, g/kg DM	17.3 ± 1	20.4 ± 1.6	0,06
Na, g/kg DM	2.7 ± 0.5	2.4 ± 0.3	0,69
S, g/kg DM	2.6 ± 0.1	2.3 ± 0.1	0,84
Fe, mg/kg DM	181.7 ± 13.2	186.0 ± 29.1	0,45
Mn, mg/kg DM	114.5 ± 5.6	114.5 ± 11.5	0,50
Zn, mg/kg DM	123.1 ± 12.3	112.3 ± 16.6	0,70
Cu, mg/kg DM	22.7 ± 2.7	20.9 ± 2.6	0,68
CAD, mEq/kg DM	203.5 ± 25.6	275.0 ± 39.6	0,08

[1] of intake capacity

[2] of energy requirement

4.3. Energy intake and energy balance

One of the parameters studied in one day feeding control was energy balance. The mean value for energy balance for both rations together was 156 % (Appendix 5). Mean value for the two feeding strategies respectively can be found in table 4. Results for all rations, even far-off rations, for energy balance can be found in figure 1. Farm 4, 7, 9, 10, 16 and 20 had the same ration during the whole dry period.

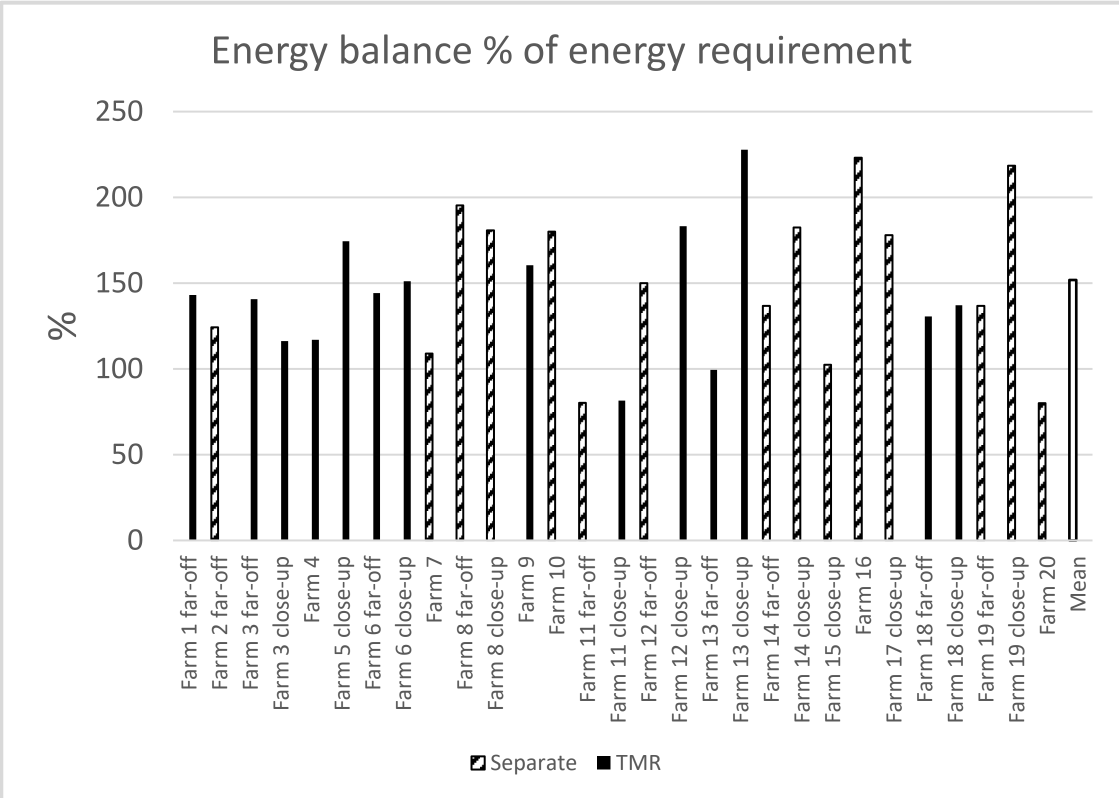

Figure 1. Results of energy balance (% of energy requirement) from one day feeding controls

In figure 2 the results for net energy can be found for each farm. Mean value for all rations was 80 MJ/day. Mean values for separate and TMR respectively can be found in table 4.

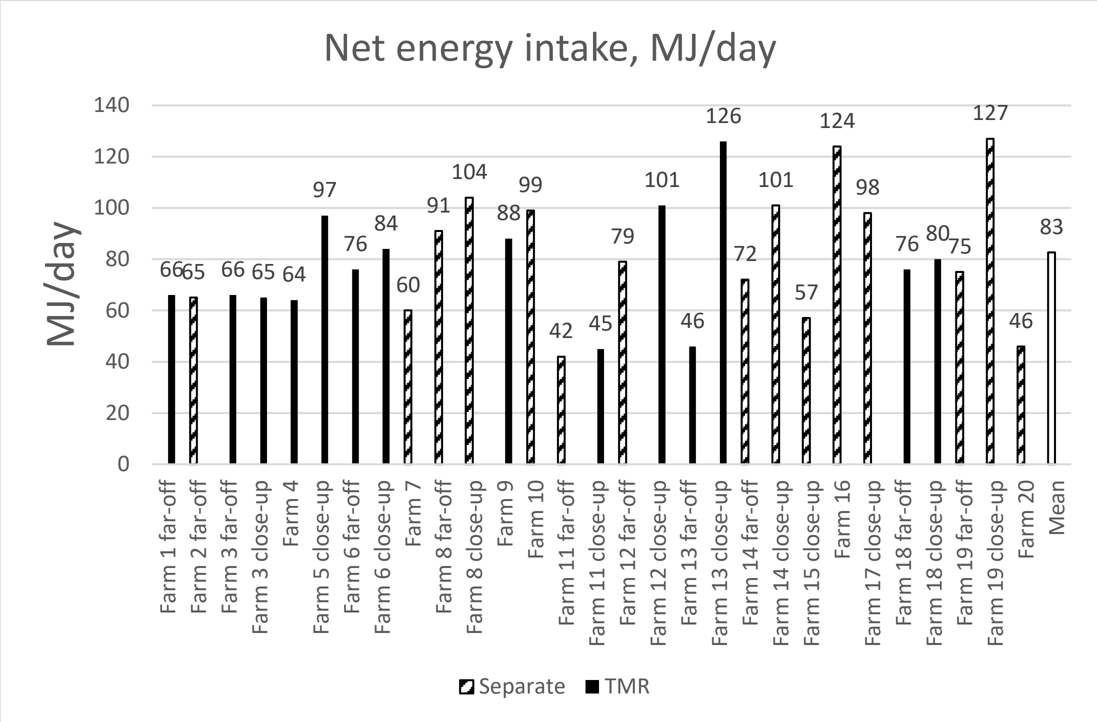

Figure 2. Results of net energy per cow (MJ/day) from one day feeding controls

4.4. Water analyses

Results from water analyses can be found in Appendix 6. Samples from 12 farms were included in the data. Based on daily intake of ions from both water analysis and one day feeding control, the CAD value was calculated, results are presented in Appendix 7. In complete feed and water intake mean value for CAD was 198 mEq/kg DM (N = 16).

4.5. Urine pH

There was no effect of feeding strategy on urine pH (TMR = 8.12 ± 0.05 vs separate = 8.12 ± 0.06). There was a significant effect of CAD on urine pH ($p<0.006$) with an increase in urine pH in relation to an increase in CAD (figure 3). Since some urine samples were analyzed with pH paper and then had a different scale for these samples, some samples got the result "above 8" and these values could not be used in the statistical model. Therefore, an average value was calculated for all results with more than 8. The mean value was 8.25, which means that all “over 8” results were replaced by 8.25.

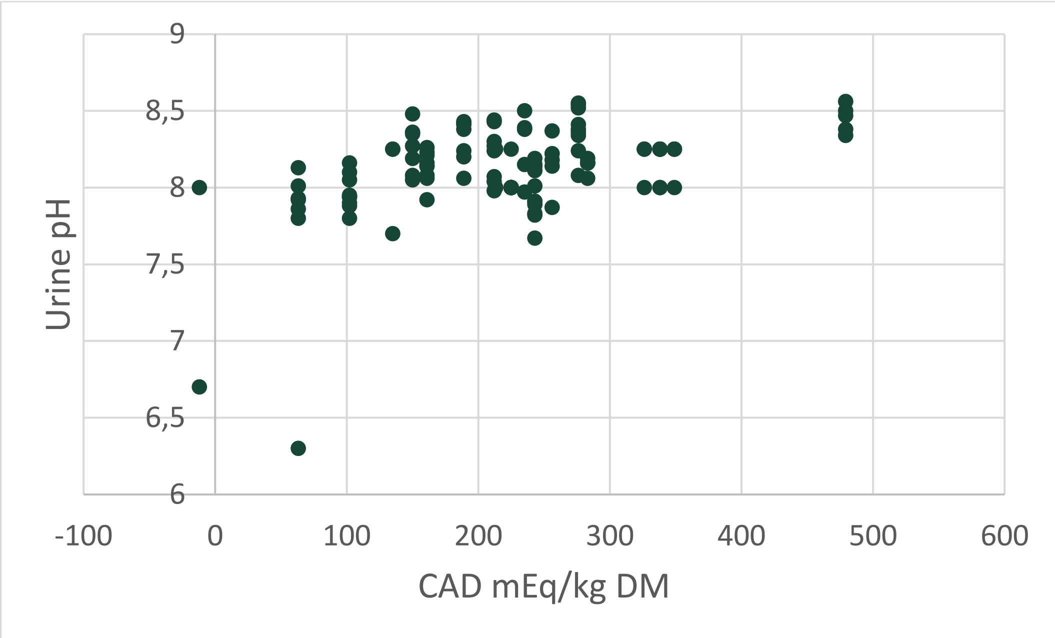

Figure 3. CAD mEq/kg DM vs. urine pH

It also showed a significant effect (<0.01) if the two outlaying values were removed, 6.3 and 6.7.

4.6. BHB

Mean value from four months over the percentage (%) of multiparous cows with elevated values BHB in milk > 0.15 mmol/l can be found in figure 4. The number of cows which the calculation was based on is also presented in the figure. The values are from the monthly sample milkings from January 2020 to April 2020. Calculations from farm nine are missing.

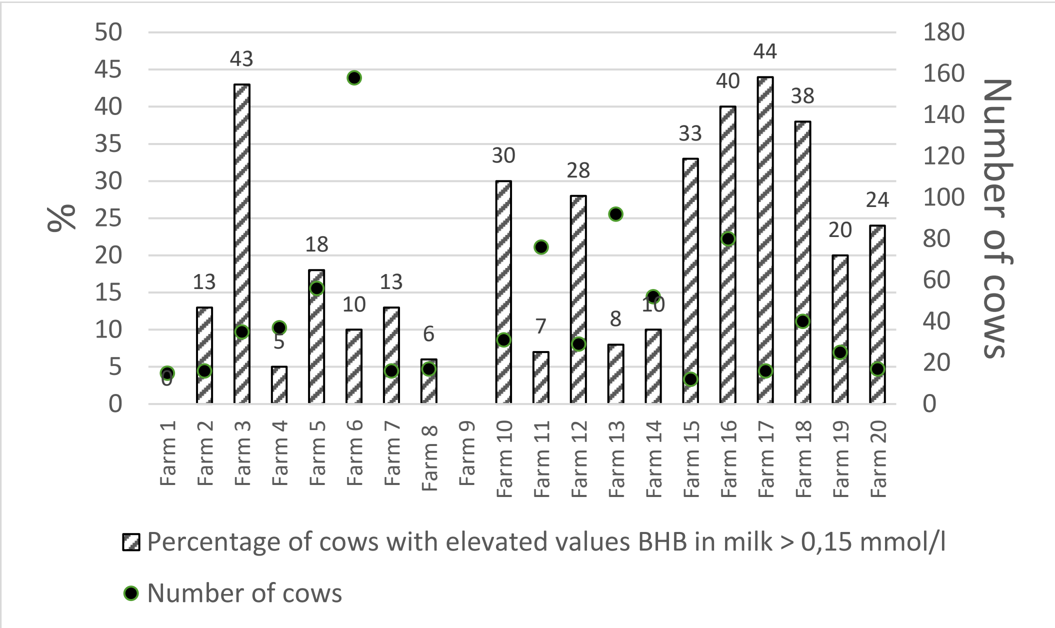

Figure 4. Percentage (%) of multiparous cows with elevated values BHB in milk > 0.15 mmol/l. The values were from the monthly sample milkings, a mean over four months

Mean value from four months over the percentage (%) of primiparous cows with elevated values BHB in milk > 0.15 mmol/l can be found in figure 5.

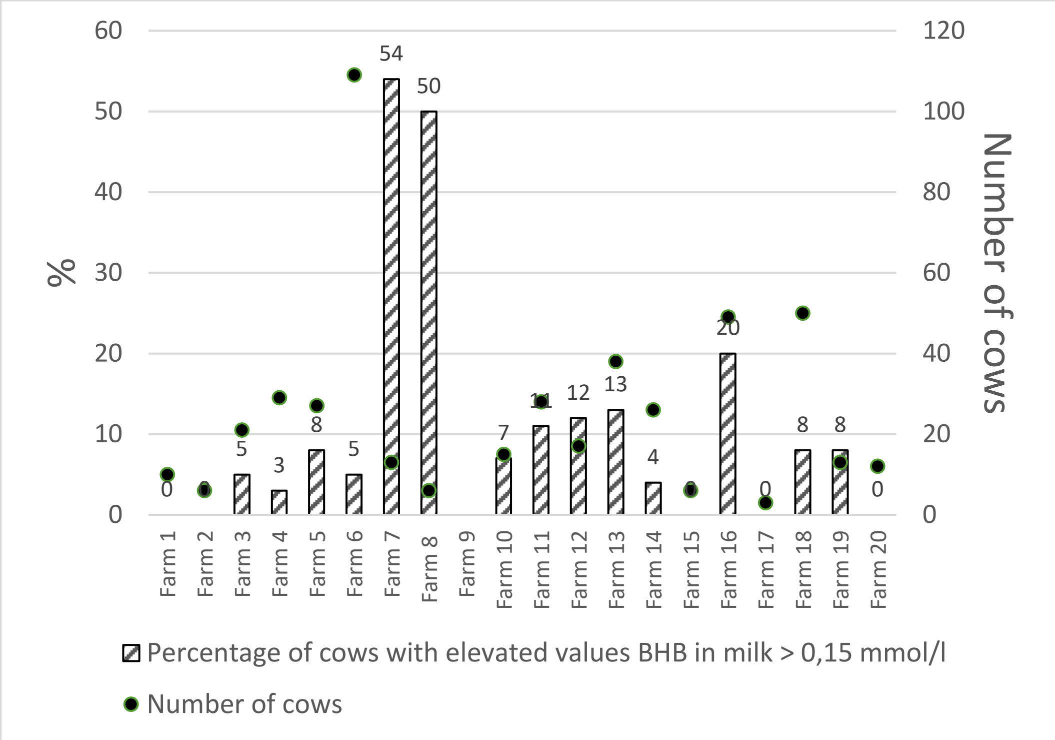

Figure 5. Percentage (%) of primiparous cows with elevated values BHB in milk > 0.15 mmol/l. The values are from the monthly sample milkings.

4.7. Body condition score

A total of 157 assessments were made (TMR = 103 vs Separate = 54). The percentage of animals assessed on the farms varied between two and ten (Table 3). There was no effect of feeding strategy on body condition score. About 76 % of the cows had a body condition score of 3 to 3.5 (Figure 6). Body condition was scored on 157 dry cows.

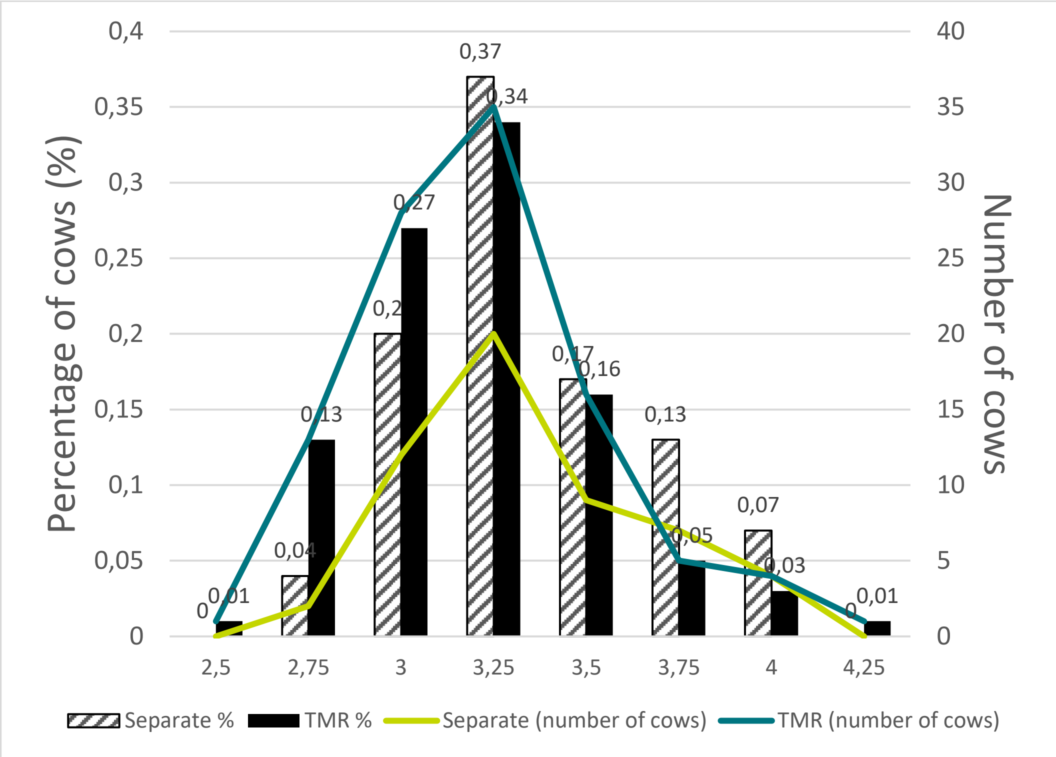

Figure 6. The percentage of dry cows (%) for the different body condition scores

4.8. Milk fever

In total, 71 multiparous cows at the 19 farms were treated for milk fever in 2019 (Min = 0 and Max = 16). Values were missing for farm nine. In figure 7 the percentage of cows that received veterinary treatment for milk fever in 2019 based on the number of calvings during 2019 per farm are presented.

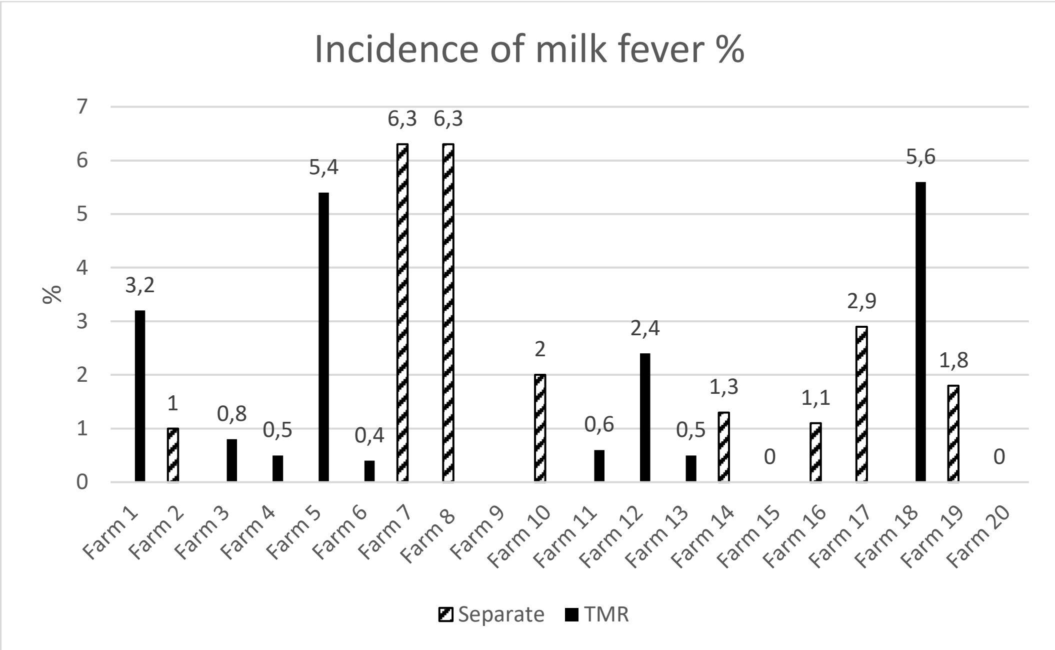

Figure 7. The percentage (%) of animals that received veterinary treatment for milk fever in 2019

4.9. Dry period length

Mean value for dry period length was 57 days (Min = 35 days; Max = 122 days). In figure 8 the number of animals and their length of the dry period are presented. 75 % of the animals have a dry period between 43-68 days.

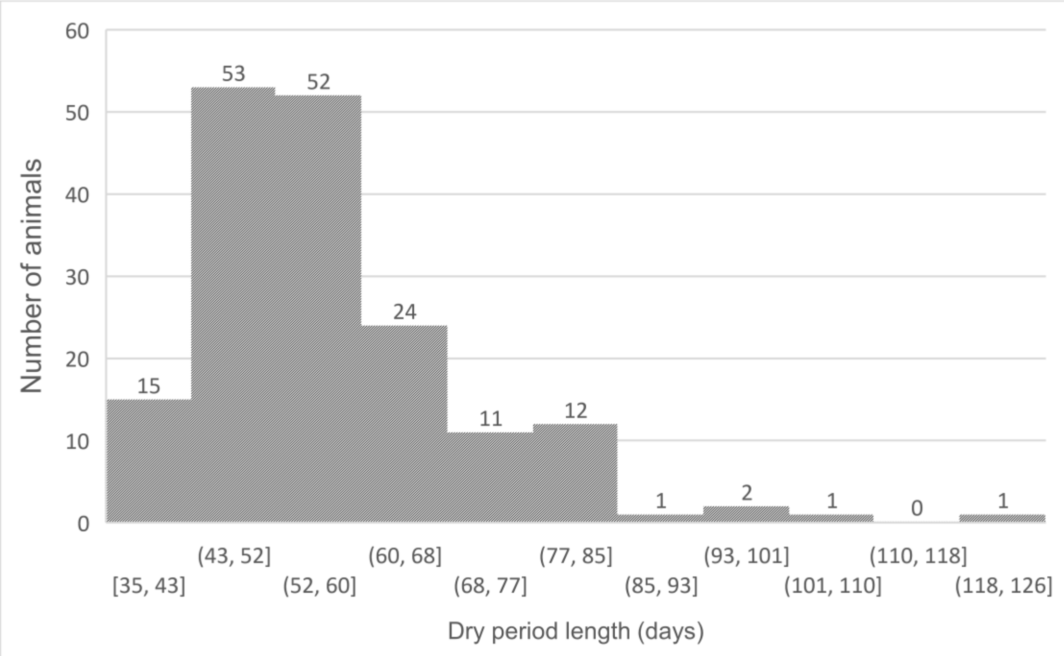

Figure 8. Dry period length

5. Discussion

5.1. Management

Farms that used the far-off/close-up strategy often gave the dry cows in the close-up group the same feeds as the lactating cows or a mix with it. The reason behind was that the cows and the rumen microflora got used to the feed they will have after calving. That was in accordance with the recommendations of Drackley and Guretzky (2007). Simultaneously, some farms let the dry cows go together with the lactating cows the last weeks before calving and thus they eat exactly the feeds for the lactating cows. It was an abrupt transition to more energy-rich feed but at the same time a preparation for the coming calving. The most important thing is to find the more correct energy balance to be well prepared when milk production start (Dann *et al*., 2006). Management at the participating farms differs greatly in most parameters investigated in this study, for example feeding, housing and disease prevention. The dry cows had sometimes been divided into a far-off and a close-up group, while on other farms they were housed in the same group throughout the entire dry period. Sometimes they are housed together with pregnant heifers, sometimes separately. One thought that arose during the farm visits was that it is the available buildings that limited how the dry cows were housed. Often a new barn is built for the lactating cows and the dry cows are housed in the old buildings.

5.2. One day feeding control

Five feed rations did not meet the recommendation for NE which was 60.3 MJ/day for a dry cow weighing 700 kg and 270 days of gestation and had a value below (Nielsen & Volden, 2011). Four of these rations also had a low energy balance which was connected to the NE intake. The last ration had a good energy balance of 102 %. Overall the recommendations for the feed parameters was well followed, including PBV (between 0 and 40 g/kg DM) and NDF (above 400 g/kg DM). For example, NDF, the rations had enough of it in almost all rations and the study by Mann *et al*. 2015 explains that a high fiber diet decrease the risk for negative energy balance. The recommendation for CAD -150 to 0 mEq/kg DM during the last 3-4 weeks before parturition (Nielsen & Volden, 2011) was difficult to fulfill. Only one ration had a value that was within this range and other rations was too high.

Based on the one day feeding controls, the feed rations had sufficient amounts of minerals except for P, Na and S for some rations (Spörndly, 2003; Nielsen & Volden, 2011). However, it was quite close to the minimum value for these minerals (Appendix 5). Recommended amounts for Fe, Mn and Zn differ between Spörndly (2003) and Nielsen & Volden (2011) where there was a higher recommendation in Norfor (Nielsen & Volden, 2011). The recommendation is almost doubled in Norfor compared to Spörndly (2003). This is confusing since both refer to the same source NRC (2001). The two farms that not provided dry cow minerals in the ration to their dry cows still had sufficient amounts of minerals in the ration. For vitamins, three rations were below the recommended amount of vitamin A and two rations were below the recommended amount of vitamin E. For vitamin D, as many as 20 rations were below the recommended value. Since vitamin D has a function in Ca absorption, deficiency can impose a risk of milk fever (Goff, 2008).

The feeding strategies, TMR and separate feeding, had no effect on the feed parameters as expected. However, there was a tendency for TMR to have an effect on CAD (TMR = 204 ± 26 vs separate = 275 ± 40, $p<0.08$). As the farms within each feed strategy had different feed rations, larger variability within feeding strategy than between the strategies. A study with more herds in both feeding strategies would be interesting to follow and see if the variables would differ between feeding strategies.

5.3. Energy balance

The recommendation for energy balance at parturition is 100%, which most of the rations were high above (Nielsen & Volden, 2011). Only two rations were close to 100% and three rations were below 100 %. Figure 1 shows clearly that many rations had too high energy balance which can lead to complications around calving and disease outbreaks in early lactation (Garnsworthy, 2007). The ration with the lowest energy balance value had a low DM on the silage and it had rained a lot shortly before the DM sample was taken which probably had an effect on the result. Remaining farms with a low energy balance also had a low intake of NE per day. Since most rations were high above the recommended energy balance, there was also a risk that the animals will instead become too well supplied. The negative energy balance after calving can be worsen with the high amount of energy most of the dry cows are supplied with (Garnsworthy, 2007) and therefore impact DMI, health and milk yield negatively.

5.4. Water analyses

Test answers from 8 farms were missing because the samples were not analyzed in time. Calculation of the CAD value for feed and water together was performed to see if the water components affected this, which it did not do for the 12 farms. The value of CAD when water was included was the same as for feed or differed from -4 to +9 mEq per kg DM (Appendix 6).

5.5. Urine pH

Urine pH and dietary CAD was not affected by feeding strategy. All samples except two, were above pH 7.5 which is high above the limit values; pH 5.5-6.5 (Lopera *et al*., 2018). The two samples that differed were at pH 6.3 (TMR) and 6.7 (separate feeding), which means that only one sample was within the recommended values. Urine pH is affected by the feeds CAD value which was recommended to -150 to 0 mEq/kg DM during the dry period (Nielsen & Volden, 2011). It was found that CAD had a significant effect on urine pH ($p<0.006$) which was excepted. Only one farm had a feed ration with a negative CAD value which can explain the result of the pH samples. The cow with urine pH 6.7 was from the farm with the negative CAD value of the feed ration, -12 mEq/kg DM. The other cow with a low urine pH, 6.3, was given a diet with a CAD value of 63 mEq/kg DM.

One thing to keep in mind is that urine pH measurements were made with both pH paper and pH meter because the electrode on the pH meter broke during a farm visit. On that farm, urine samples were collected in jars for subsequent measurement (N = 4). The urine samples were at room temperature for three days before the pH was measured. None of the farmers mentioned that they aimed for a more acidifying diet for the dry cows, which is also important to keep in mind when studying the results of urine pH.

5.6. BHB

The concentrations of BHB in both milk and blood may indicate the animal's energy supply (Mann *et al*., 2015). An elevated value in early lactation may indicate a negative energy balance around parturition. The data for concentrations of BHB were taken from the test milking during the months the project has been run, which may give a small indication of how the herds are doing. It can be seen in the graphs (figure 3 and 4) that multiparous cows have had more elevated values of milk BHB after calving compared to primiparous cows. The studies have only focused on multiparous cows, and the reason for the difference in milk BHB may be that it was more common for multiparous cows to be affected by a worsen negative energy balance. The size of the farms differed markedly as we have a difference from around 50 to 500 cows which affects the number of calvings. One farm had two calvings during one month where both cows had increased values of milk BHB hit hard as the result will be 100%. Another farm which had two cows with elevated values but over 20 calvings showed a lower percentage result. To have a more reasonable conclusion, more data is needed over a longer period of time. Since elevated blood BHB values can indicate, for example, hyperketonemia, blood BHB can be a benchmark to use (Duffield *et al*., 2009). The study defines that a blood BHB value of > 1.4 mmol increases the risk of hyperketonemia. However, this is for blood plasma which is important to keep in mind and for milk BHB the critical value is 0,15.

5.7. Body condition score

The number of animals assessed on the farms varied due to how many cows that were dried off at the visit, but with a maximum of ten cows. Most cows had a body condition score between 3.0-3.5 which follows the recommendations from advisors at Växa Sverige and the reviews by Roche *et al*., 2009 and Roche *et al*., 2013. They differ from the article by Garnsworthy (2007) which describes that body condition score should be lower at parturition. The reviews are made by authors from New Zealand where pasture-based milk production is most common (Roche *et al*., 2009; Roche *et al*., 2013). This may be why the recommendations differ. The reason can be that in New Zealand a higher body condition score at parturition is wanted as it is more difficult to control how much the cows eat when grazing. The variation can also depend on which breed is used in the different countries when, for example, in Sweden, SRB are used (34 % of the Swedish dairy cow population according to Växa Sverige, 2020b) which generally have a higher body weight in relation to body size, compared to Holstein (57 % of the dairy cow population, Växa Sverige 2020b). This can then be reflected in the recommendations. No one recommends that the cows should have a body condition score over 3.5 which 13 % of the cows in this study had. The risk of diseases and a reduced DMI in early lactation are therefore present for these animals according to the literature (Garnsworthy, 2007). Furthermore, since many farms had a very high energy balance, it can lead to a higher body condition score for the dry cows. It was not investigated if there was any correlation between body condition score and energy intake which would have been interesting.

5.8. Milk fever

Since the incidence of milk fever are from 2019, before the data collection, no pressure that farmers should be extra strictly to report into the Swedish milk recording scheme could not be made. The farms that had zero reported cases of treated milk fever may actually have had no cases of milk fever, it can also indicate that the veterinarian has not reported the numbers or only reported it in the journal at the farm. Milk fever most commonly affects multiparous cows, the 71 animals affected by milk fever in 2019 were all multiparous cows. Eighteen of the farms use preventative actions to reduce the risk of milk fever. In summary, no large proportion of cows in these farms were treated for milk fever during the previous year.

5.9. Dry period length

Information about dry period length were available from 11 farms (N = 172). The mean value for the length of the dry period was 57 days, which is reasonable since most farms today plan for a dry period of 60 days. In the literature, a shorter dry period (4 weeks compared to 8 weeks) has proven to be better at manage the negative energy balance that cows often end up with postpartum (Weber, *et al*., 2015; Andrée O'Hara *et al*. 2019). The studies have compared BHB and NEFA concentrations in the blood to be able to conclude this. However, it appears that the milk yield increases over a longer period after calving with a longer dry period (up to 12 weeks). Most of the animals had a dry period around the most common, 60 days, which makes it difficult to conclude if dry period length have had any negative impact on BCS, milk fever, milk BHB and colostrum yield. According to the new recommendations (Växa Sverige, 2020) about a dry period of 7-8 weeks, the farms are following this in the present study.

5.10. General discussion

Since the data was collected on twenty farms where each individual farm was responsible for the documentation, there are things to consider when valuing the data. One source of error that can occur with this kind of data collection is that when data is collected by at least twenty people, they are most likely to interpret instructions differently. The routines at the farms were very different which can affect how and when the tables were filled in, even if they had instructions about it. The same applies when we entered data in Microsoft Excel if the documentation is difficult to interpret and then false values are written down. One reason why data were probably missing for dry period length was that some of the farmers have used old instructions where the parameter dry period length was missing and therefore these farms did not document this. Generally, more farms are needed to get a more statistically reliable result for all parameters. Since the study showed great variation between farms in terms of both management and feeding, it provides a lesson for future research and advice.

6. Conclusion

Differences between TMR and separate feeding were not found. Management of dry cows differed but some parameters as for example dry period length and dry cow treatment was also virtually similar between the participating farms. The one day feeding controls showed that the recommendations were followed in general. The energy balance and CAD were difficult parameters to get to a desirable value for in the feeding ration. The high CAD values in the feeding rations resulted in high pH values in the urine and CAD was also found to have a significant effect on urine pH. The energy balance for most farms was well above recommended. TMR and separate feeding had no effect on the parameters in the feeding rations, body condition or urine pH.

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Populärvetenskaplig sammanfattning

Sinperioden förbereder kon för den kommande laktationen. Tiden kring kalvning är en kritisk period vilket innebär att skötseln och utfodringen av sinkorna har en betydande roll. Hur sköts våra sinkor ute på svenska mjölkgårdar och vad har utfodringen för betydelse för hull, pH i urinen under sinperioden samt energibalansen innan kalvning?

Grundtanken bakom studien var att dagens foderrekommendationer för sinkor inte är särskilt uppdaterade och rådgivare i Sverige önskar att riktlinjerna bör vara tydligare. Ytterligare en fundering är om lantbrukarna följer rekommendationerna och hur deras skötselrutiner ser ut. Ett stort fokus ligger på våra lakterande kor vilket gör att sinkorna stundtals faller mellan stolarna. Syftet med studien var att jämföra separat utfodring med fullfoder för att se dess påverkan på pH i urinen samt hull under sinperioden. Vid separat utfodring utfodras grovfoder och kraftfoder separat medan fullfoder innebär att det utfodras tillsammans i en blandning. Foderstater, energibalans innan kalvning samt skötselrutiner har också jämförts.

En fältstudie på tjugo svenska mjölkgårdar har utfördes där lantbrukarna har dokumenterade information kring gårdens kalvningar under två månader. Ett gårdsbesök gjordes på varje gård där ytterligare data samlades in. Lantbrukarna fick besvara frågor kring inhysning, skötsel och foderrutiner under gårdsbesöket. Foderprover och vattenprover togs in för analys. Endagars utfodringskontroller beräknades på varje gård för att få fram vad sinkorna utfodrades med per dag samt hur mycket de faktiskt åt upp. Resultatet kan användas för att bedöma om foderstaterna uppfyller de rekommendationerna som finns.

Resultatet visade att separat utfodring och fullfoder inte hade någon påverkan på de granskade parametrarna. Energibalansen och katjon-anjon balansen var svåra parametrar att uppfylla i foderstaten. Övriga foderparametrar följde rekommendationerna i nästan alla foderstater. Katjon-anjon balansen hade en signifikant effekt på pH i urinen där ett högre värde i foderstaten medför ett högre pH i urinen. Skötselrutiner skiljer sig mellan gårdarna men vissa faktorer är också lika. En studie med fler deltagande besättningar skulle behövas för att kunna få ett mer statistiskt säkert resultat för de undersökta parametrarna.

Appendix 1 Tables for farmers documentation

Cow-ID			
Date of calving			
Amount 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]			

Calf-ID			
ID-mum			
Birth date + approximately time			
Birth weight/breast size[1]			
Calf temperature at birth[2]			
Amount 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]			

Appendix 2 Additional information for the tables

Table - calf

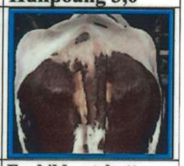
1. Breast size in cm. If you use a hanging scale also enter the birth weight in kg.
2. Calf temperature at birth - as fast as possible after birth. Always use lube or ointment on the thermometer. Carefully insert the thermometer into the calf's rectum. Push carefully the thermometer against the intestinal wall, so that the thermometer not measure the temperature of the feces. Notice the time.
3. Vitality at birth (lazy/normal/alert). Estimates when the first meal is given.
   Weak calves lie down most of the time, needs to be lift up at feeding and are not active in search of food.
   Normal calves stand up in 3-4 hours age and stand up spontaneously with feeding and have well working sucking reflex.
   Alert calves stand up and walks in one hour of 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.

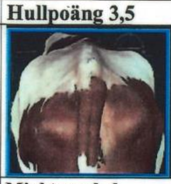
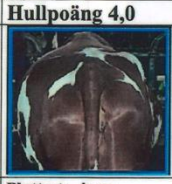
Table - cow

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 Bovicalc, X-zelit or similar?
10. Calving difficulty. Evaluate as below according to Swedish milk recording scheme.
    11. Easy, without help
    12. Easy, with help
    13. Difficult, with help from veterinarian
    14. Difficult, without veterinarian
    15. Data is missing

Appendix 3 Body condition form

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				 U-formad grop under svansen
Dåligt hull, tydligt framträdande skelett	2.00	 Enskilda utskott syns	 Tydligt insjunket	Tydligt framträdande	
	2.25				
	2.50	Enskilda utskott syns ej, ryggraden är tydligt benig		Något beniga	Första antydan till fettlager
	2.75		 Mjuk konkav kurva		
	3.00			Mjuka konturer	 Grund svansgrop med tunt fettlager
Medehull	3.25	Mjukt rundning över ryggraden, utskotten syns ej		Täckta av vävnad	
	3.50		 Jämn sluttning		
	3.75			Rundade med fett	Fettfylld svansgrop, antydan till veckbilding av fett under svansen
	4.00	Plan yta, inga synliga utskott	 Nästan plan		
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 for documentation at farm visits

Calves

Housing

- 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.

Management

- Which feed do the calves got beyond milk - hay/pellets for example.
- Do the farmer 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 is offered to the calf.
- Other milk routines during the first month - how much milk fed in each meal and how many milk meals per day.
- Do the calves have same feed allowance during summer and winter.

Dry cows

Housing

- The flow from drying off until parturition – how is the dry cows moved.

Management

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

Feeding

- 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 pregnancy.
- 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 is the heifers moved.

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 visits

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

Housing

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

Appendix 5 Results from one day feeding controls

Parameter	Mean	Min	Max	Norfor min	Norfor max
DMI, kg DM/day	14,0	7,4	23,9		
Fill value, % of intake capacity	103	56	195		
Net energy intake, MJ/day	80	42	127	55	
Energy balance, % of energy requirement	148	80	228	100	101
PBV, g/kg DM	21	-5	53	10	40
NDF, g/kg DM	464	349	555		
Ca intake, g/day	87	40	182	36	
P intake, g/day	47	20	84	22	
Mg intake, g/day	52	28	102	14	
K, g/kg DM	17.8	9.1	28.6	5,2[1]	
Na, g/kg DM	3	1	6	1[1]	
S, g/kg DM	2	2	3	2	
Fe, mg/kg DM	189	96	283	50	
Mn, mg/kg DM	113	57	166	40	
Zn, mg/kg DM	123	70	229	50	
Cu, mg/kg DM	22	12	44	10	
CAD, mEq/kg DM	214	-12	479	-150	0
Vitamin A, 1000 IE/kg BW	258	45	782	110	
Vitamin D, 1000 IE/kg BW	28	10	80	30	
Vitamin E, 1000 IE/kg BW	4.3	0.8	12.8	1.6	

[1] Spörndly (2003)

Appendix 6 Results from water analysis and advice for drinking water for humans

Farms	SO_4 mg/l	Cl mg/l	F mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Si mg/l
Farm 1	13	15	0.08	24	2.7	9.8	1.1	2.7
Farm 2	16	9.3	0.23	26	4.7	7.1	2.2	8.2
Farm 3	27	12	0.31	13	3.2	22	2.2	7.3
Farm 4	86	500	<0.05	53	20	360	5.1	6.8
Farm 5	70	120	0.62	32	20	140	12	10
Farm 6	50	260	<0.05	28	4.8	240	2.2	7.8
Farm 7	49	120	0.56	55	11	100	5.5	6.2
Farm 9	66	14	0.53	64	8.7	11	2.3	8.2
Farm 10	17	7.4	0.62	31	5.4	6.8	1.4	8.2
Farm 18	110	92	<0.05	110	32	78	23	8.9
Farm 19	11	5.6	0.67	28	5.2	8.3	2.8	6.6
Farm 20	8.6	16	0.41	22	2.3	10	0.94	6.3

Parameter	Unit	Serviceable with remark	Unsuitable	Comments
SO_4	mg/l	100	-	Risk of corrosion
		250		Risk of taste change and diarrhea for sensitive children
Cl	mg/l	100	-	Values may depend on road salt, seawater or relic water
				Risk of taste change
		300		
F	mg/l	1,3		>0,8 limited caries protection
				0,8–1,5 caries protection
			6,0	Risk of fluoride storage in bone tissue
Ca	mg/l	100	-	No health restrictions
Mg	mg/l	30	-	Risk of taste change
Na	mg/l	100	-	Values may depend on seawater or relic water
		200		Risk of taste change
K	mg/l	12	-	May be due to contamination or in some cases natural geological origin

Source: Livsmedelsverket (2015).

Appendix 7 Results of CAD for feed and for feed and water

Farms	CAD for feed mEq/kg DM	CAD for feed and water mEq/kg DM
Farm 1 far-off	141	139
Farm 2 far-off	174	173
Farm 3 far-off	181	179
Farm 3 close-up	225	230
Farm 4	63	60
Farm 5 close-up	256	265
Farm 6 far-off	241	250
Farm 6 close-up	213	217
Farm 7	479	479
Farm 9	212	211
Farm 10	189	186
Farm 18 far-off	161	160
Farm 18 close-up	161	160
Farm 19 far-off	-12	-16
Farm 19 close-up	135	135
Farm 20	349	347