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Responses of dams versus non-nursing cows to machine milking in terms of milk performance, behaviour and heart rate with and without additional acoustic, olfactory or manual stimulation

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ABSTRACT

There is increasing interest in dam rearing where dairy cows are milked and nurse their calves additionally. One shortcoming in dam rearing is the impaired alveolar milk ejection, which lowers the milk yield obtainable by machine milking. In this study dams and non-nursing dairy cows were compared during milking concerning machine collected milk yield, machine-on time, milk flow characteristics, milk fat content, somatic cell score (SCS), agitation behaviour, heart rate (HR) and heart rate variability (HRV). The effect of acoustic (played-back calf calls), olfactory (hair of the own calf) and manual stimulation (teat massage) on these parameters were examined in the parlour in comparison to routine milking. Between milking times calves of 15 dairy cows had permanent access to the cows' lying area and were allowed to suckle ('contact'). 'Control' cows were separated from their calf within 12 h after birth (n = 22). All animals were milked twice daily in the same parlour. The experiment was conducted in the second month of lactation. Mixed models were applied. Over all treatments machine collected milk yield (−9.9 kg/milking), fat content (−0.66%) and milk flow characteristics of dams were lower than in 'control' animals (all tests: $p < 0.0001$, effect size $r > 0.70$). SCS as indicator of udder health did not differ between groups. There was no impact of 'contact' on rumination, stepping, kicking, HR and some parameters of HRV (RMSSD, SDNN, HF%) in the parlour. Dams showed a tense head position ($p = 0.0007$, $r = 0.56$) and defecated ($p = 0.0125$, $r = 0.50$) at more milkings than cows without calf contact. On the other hand, some characteristics of HRV differed between 'contact' animals and the 'control' (LF%, LF/HF; $p < 0.05$, $r > 0.30$), indicating a higher vagal activity in dams. Reason for this may be an in general higher vagal activity due to suckling, which could also result in higher gut motility and therefore a higher defecation frequency. None of the treatments had great impact on the animals. Manual stimulation increased the mean milk flow during the main milking phase. However, this is possibly due to technical differences compared to vibration stimulation without effects on harvested milk. Acoustic stimulation led to lower SCS compared to routine milking, but only in dams (interaction: $p = 0.0023$). In conclusion, it was not possible to enhance milk let-down in dams with free calf-contact through acoustic, olfactory and manual stimulation.

1. Introduction

On most dairy farms with *Bos taurus* cow and calf are separated soon after birth which can be criticized from an animal welfare perspective (e.g. von Keyserlingk and Weary, 2007). Consumers in many countries are concerned about early separation (Boogaard et al., 2008, 2010; Ventura et al., 2013). There is growing interest in allowing suckling and additionally milking the cows (Busch et al., 2017; Hötzel et al., 2017). In so-called dam rearing, different nursing strategies are possible (reviewed by Johnsen et al., 2016). A major challenge of dam rearing is incomplete alveolar milk ejection during machine-milking (e.g. Boden and Leaver, 1994; de Passillé et al., 2008; Mendoza et al., 2010) and thus the reduced amount of saleable milk. In addition, milk fat content and milk flow are reduced (e.g. Barth et al., 2010; Mendoza et al., 2010).

Milk is produced continuously in the alveoli of the udder (reviewed by Bruckmaier, 2001). In cows milked twice daily without suckling, the cisternal milk fraction stored in the udder is nearly 20%. This milk is obtainable without milk ejection. However, tactile stimulation of the udder is necessary in order to induce the neuro-endocrine milk ejection

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reflex targeting the fraction stored in the alveoli. Oxytocin is released and if a certain threshold is reached, the shift of alveolar milk into the cistern is provoked, where it can be collected (Bruckmaier, 2001). The tactile stimulus of pre-milking and udder cleaning is mostly sufficient to induce alveolar milk ejection in non-nursing cows (Bruckmaier and Blum, 1998). Cause for alveolar milk ejection problems in dams are not completely understood, but some mechanisms have been detected. Dams release less oxytocin during machine milking than non-nursing cows (Akers and Lefcourt, 1984; de Passillé et al., 2008). On the other hand, they have higher blood oxytocin levels when nursing the own calf compared to non-nursing cows at machine milking (Akers and Lefcourt, 1982; Bar-Peled et al., 1995; de Passillé et al., 2008; Lupoli et al., 2001; Tancin et al., 2001). However, for dams nursing an alien young, no (Hernandez et al., 2002: goats; Silveira et al., 1993: beef sucklers;) or a smaller oxytocin increase (Bar-Peled et al., 1995: dairy cows) is reported. The exclusive response towards the own offspring is likely due to oxytocin being an important hormone in maternal bonding and maternal behaviour (reviewed by Kendrick, 2000; Uvnäs-Moberg et al., 2001). A further possible aspect affecting milk ejection is the occurrence of stress. For instance, Schneider et al. (2007) found indications for higher agitation (combination of eye-wideness, rumination and head position) during milking in dams compared to non-nursing cows. However, the knowledge about the well-being of dams during milking is insufficient.

Peeters et al. (1973) observed milk ejection during calf-contact, when the udder was not touched, in primiparous and multiparous cows, but mainly if the animals showed maternal behaviour towards their offspring. The authors conclude that calf-related stimuli such as sight, sound and odour are suitable to induce milk ejection, even without the experience of suckling. Therefore, calf-associated stimuli in the parlour might alleviate problems with milkability. Barth et al. (2010) tested the influence of olfactory stimulation in the parlour on milk let-down of dams with a cloth their calves were firmly rubbed with before. No effect was found, but it remained unclear whether animals did not perceive the odour, or calf-odour did not influence alveolar milk ejection. In a prior study we examined the behavioural response of cows with and without calf-contact on hair of the own calf, hair of an alien calf and a control without calf-hair (Zipp et al., 2016). Increased responses towards samples with calf-hair suggested that this kind of olfactory stimulation was perceived by the animals. Pollock and Hurnik (1978) stimulated non-nursing cows acoustically with played-back calf calls during udder preparation and thereby gained more milk. Also manual teat stimulation, for example hand milking, can lead to higher oxytocin release (Gorewit et al., 1992), higher milk yield and milk fat content in non-nursing animals (Svennersten et al., 1990). So far it is not known if these kinds of stimuli are able to enhance milk let-down in dams during the milking process.

The aim of this study was therefore to compare milk yield, milk flow characteristics and milk composition between dams and non-nursing dairy cows under conditions of routine milking versus milkings with enhanced olfactory stimulation with calf hair, acoustic stimulation with played-back calf calls or manual teat massage before machine milking. In addition, we took into account agitation behaviour, heart rate and heart rate variability during the different treatments in the parlour as potential stress indicators.

2. Animals, material and methods

2.1. Animals, housing, management and experimental groups

The experiment was conducted from November 2010 to May 2011 at the research farm of the Thünen-Institute of Organic Farming in Trenthorst, Germany in two separate horned herds of 45–48 German Holstein black-and-white and 45–48 German Red Pied cows. They were housed in two identical sections of a loose housing stable with cubicles and were managed in the same way. All animals were fed a total mixed ration and additionally received concentrate provided by automated concentrate feeders according to their automatically measured milk yield (max. 8.5 kg/d, for details see: Wagner et al., 2012).

The ‘control’ group consisted of 22 animals (three primiparous and ten multiparous German Holstein, two primiparous and seven multiparous German Red Pied). They calved in a calving pen, one for each cow-calf-pair, were separated from their calf within the first 12 h after birth, and were integrated in the milking herd one day after parturition. Milking twice daily started after calving. ‘Control’ calves were group-housed. Colostrum was supplied by bottle and afterwards calves were trained to drink at an automatic milk feeder.

The ‘contact’ group consisted of 18 animals (four primiparous and seven multiparous German Holstein, two primiparous and five multiparous German Red Pied). However, due to cases of clinical mastitis and death of one calf, one primiparous and one multiparous German Red Pied and one German Holstein heifer were excluded from analysis, so that in the end data from 15 dams were analysed. ‘Contact’ cows also calved in the calving pen, but stayed there for the first five days together with their calf, except for milking and the main feeding time after milking twice daily. Calves were bottle-fed 2 L colostrum immediately after birth and allowed to suckle the dam. After five days they were integrated into the dairy herd. Calves were housed with ‘control’ calves in the calves’ area where hay, silage, concentrate as well as water were provided. ‘Contact’ calves had no access to the automatic milk feeder, but could enter the dairy cows’ lying area unrestrictedly through a transponder controlled selection gate. Thus, ‘control’ cows had also contact with the ‘contact’ calves, but no nursing event was observed in ‘control’ animals.

2.2. Preparation and application of treatments

Starting between the fourth to fifth week of lactation, stimulation tests were carried out for three consecutive weeks (26–50 days in milk). The experiment started for each animal on a Monday, therefore the day of lactation of the animals varied (contact: 30 ± 2.3 d; control: 29 ± 2.3 d; mean and SD). Each week one of three treatments was applied during four consecutive milkings in the 2 × 4 autotandem milking parlour (GEA, Boenen, Germany): acoustic, olfactory and manual stimulation. On four other consecutive milkings of this week routine handling was conducted. Each animal underwent the three treatments, except for six ‘control’ cows, where no olfactory stimulation was possible, because their calves had died. In all eight milkings milk yield, machine-on time, milk flow characteristics, milk composition, HR and agitation behaviour were recorded. To avoid carry over effects, there were two to four routine milkings without recording between the four recorded routine milkings and the four treatment-milkings. Milking routine consisted of manual pre-milking and cleaning of the udder (approx. 20 s in total) with a machine washed and tumble dried fabric towel, attaching and positioning of milking cluster, 40 s vibration stimulation (300 pulses min^{-1}), 38 kPa milking vacuum, automatic stripping starting at a milk flow of 800 g min^{-1} and automatic cluster removal at a milk flow lower than 300 g min^{-1}. Emptiness of udders was checked manually after automatic cluster removal and cluster was attached again when necessary. To prevent calves from intake of disinfectants, only the teats of ‘control’ cows were dipped after milking.

Acoustic stimulation consisted of played back calf calls recorded approx. 10 h after the last milk feeding from ten 2–12 week old alien calves belonging to another farm. Calf calls were played back at least from the moment cows entered the milking stall until milking clusters were removed. For olfactory stimulation, hair of the own calf was cut half a day before the first stimulation. Hair samples came from the anogenital region, hind legs and tail. For each milking, approx. 0.8 g hair was filled in one thin cloth bag with which the calves had been rubbed before (cloth: Fliselina®, Freudenberg Vliesstoffe KG, Weinheim, Germany). The bags were stored each in a glass jar at approx. 16–18 °C. When the cow entered the milking stall, the hair bag was taken out of