Stepwise development towards physiological milk harvest - a consequence of suckling technique

M. Mayntz

Mälardalens Högskola, Dep. of Biology and Chemical Engineering, SE-631 05 Eskilstuna, Sweden
E-mail: michaelm@bahnhof.se

Summary

Today's knowledge about suckling is presented. The differences between suckling and machine milking are outlined and summarised in four main areas: (i) number of milk harvests per day, (ii) adaptation of milking conditions to the degree of filling of the quarter cistern, (iii) guarantee of an empty cistern before next ejection, and (iv) adaptation of pressure application. The first three areas are discussed separately. Regular after-milking suckling is presented as a key provision.

Key words: *suckling, development, milk harvest*

Introduction

In milking technique and dairy production processes (i) defects are met with re-redesign, often resulting in new defects. (ii) The potentials of development steps or design variants are not used consequently. (iii) Some research efforts reveal low standard: Widely quoted results concerning methodology and subject matters do not hold for control. (iv) Commercial dairy production, milking technique, and mainstream dairy research meet consumers' demands concerning ethics of production defensively. In modern dairying, cow and calf are not accepted as model despite evolution having developed a perfect interaction between mammalian mothers and their offspring. The argument that the „modern dairy cow" cannot be compared with e.g., beef breeds neglects some facts: (i) The period of breeding is negligible compared with the period of evolution. Even if human selection had aimed towards that „modern dairying cow", the physiology of which is claimed to be principally different from the original *Bos taurus*, the time of selection would be by far too short. (ii) Evolution has always acted on fitness, whereas man's breeding often approached less central characteristics. (iii) Recent observational and experimental work has revealed details of the cow-calf-model (CCM) that are useful for developing milking technique and dairy production processes.

The objective of this report is to plead for acceptance of CCM. Principles of CCM offer (i) a comprehensive developmental strategy, and (ii) an offensive approach towards ethical demands. (iii) Further, they can be incorporated in today's dairy production and milking technique in a stepwise procedure, where the first steps do not demand radical re-design.

Materials and methods

Table 1 gives a summary of research concerning the cow-calf-model carried out by our laboratory.

Results

What do we know today about the cow-calf-model?

(i) A calf suckles 4-6 times per day (Sambraus 1978). Three of these meals are fixed in time: one at dawn, one in late afternoon and one around midnight (Sambraus 1978).

(ii) A calf changes teats 400 to 600 times during a suckling meal (Mayntz & Costa 1998). How long a teat is suckled uninterruptedly (referred to as bout) depends exclusively on the amount of milk available in the corresponding cistern (Mayntz & Costa 1998). There are short bouts during pre-stimulation, and a sudden increase followed by a gradual decrease of bout length during ejection. Harvesting of after-rinsing (referred to as after-stimulation) is carried out with short bouts again. After-stimulation takes about two third of a mealtime, i.e., 12 to15 minutes on average (Mayntz 1996, Mayntz & Costa 1998).

(iii) After-rinsing results from the cavern-like milk ducts (Wirz 1913). After-stimulation leaves the cavern completely empty and it probably remains so until the next ejection (Mayntz, unpublished data). After-stimulation is partially non-nutritive (Lidfors et al. 1994) and one part of the information given to the dam concerning the offspring's momentary need (Sederström et al. 2002).

(iv) The inflow into the cavern is slower that the outflow through the teat canal. Therefore it is an optimal strategy to abandon an empty teat, and to address the other ones while the first is refilled. During refilling, a teat remains un-stretched and under atmospheric pressure.

(v) A sucking calf applies a pressure differences across the teat canal between 60 and 110 kPa! Peaks of pressure difference last only for a couple of mili-seconds and are applied with a frequency of 2 to 2.4 Hz (Rasmussen & Mayntz 1998). Between those peaks, the pressure difference is decreased to almost null kPa (Rasmussen & Mayntz 1998).

(vi) The pressure difference consists of about 60 % "under-pressure" beneath the teat tip and about 40 % "over-pressure" in the teat cistern (Rasmussen & Mayntz 1998).

(vii) The length of ontogeny depends on the amount of the initial over-secretion of the cow. A *peri natal* surplus of colostrum is an evolutionary mechanism, leaving the fundamental test of fitness mainly to the offspring. That test of fitness prevents heavy investment of the mother during lactation (Fedak & Anderson 1982) into an unfit offspring.

(viii) After the end of ontogeny, a calf applies the suckling procedure for maximal secretion outlined above on all lactating teat uniformly (Mayntz 1996).

A physiological milk harvest could apply the rules of suckling for maximal secretion from the onset of lactation.

Differences between cow-calf-model and milking technique.

Table 2 summarises the main differences between CCM and milking technique. These differences can be grouped into four major areas: (i) Number of milk harvests per day, (ii) adaptation of milking conditions to the degree of filling of the quarter cistern, (iii) guarantee of an empty cistern before next ejection, and (iv) adaptation of pressure application.

Discussion

The sequence of the four areas above follows the authors view on human readiness to change thinking. Dairy scientists seem to accept technical re-design easier than new concepts about animal management. An adaptation of the vacuum application of milking technique to CCM violates the promises of no radical re-design. Therefore this area is mentioned only to complete the list. The guarantee of an empty cistern before the next ejection could be implemented easy and fast but it demands substantial change in management thinking.

Number of milk harvests per day.

Increased milking frequency and thereby a substantial increase in milk yield was the main argument at the onset of AMS-development. Compared with those hopes, the results concerning milking frequency in AMS cannot be but disappointing: average milking frequency for all cows is slightly below 2 and reaches seldom individuals values above 3 (Devir et al. 1999).

It seems that we have forgotten that animals can hardly be forced but successfully attracted. Any animal oriented strategy must return to attracting the cow to the milking stable. However, there are reasons to be afraid that culling cows under the verdict: „Unfit for AMS“ will solve these problems instead.

We repress a repulsion of cows against milking technique. In 1987 a laboratory that was fond of the biological potential of voluntary milking imitated the not yet available hardware by a separate cow stand and shift-working students. At first they trained the cows to enter the stand voluntarily by giving concentrates at every visit. After a week they started to combine those voluntary visit with milking. Two results were seen: (i) The cows dropped the frequency of visits by more than 50 % immediately and (ii) teats showed one narrow stripe of infected hyperkeratosis across the tips after a couple of days. The results became another victim of selective publication (Palmer, 2000).

Adapt milk harvest speed on degree of filling.

When phrasing our knowledge about the FIL-mechanism (e.g., Wilde et al. 1988) as a product demand for a milking process, we would say: „Get as much milk as possible over the threshold of capillarity during ongoing ejection"; i.e., speed of milking matters, however, only during those 2 to 4 minutes. Calves fulfil that demand by emptying a quarter before addressing another one and by leaving a completely empty cistern for the next ejection.

During ejection both pulsation frequency and -ratio and potentially even vacuum could be increased. Quarters get empty within a narrow period of time (Mein et al.1973). Therefore a good signal for changing vacuum application could be the cease of milk flow from the first quarter. The remaining milk from other quarters and the after-rinsing from all quarters can be stored in the cistern and harvested slowly.

Guarantee an empty cistern before ejection.

A complete udder emptying supports maximal secretion and is an essential hygienic provision, but the productivity of stripping is too low and machine stripping has revealed negative effects on udder health (IDF 1987).

If we would combine milking and consecutive suckling regularly in an after-suckling-procedure (ASP), we would get (i) a complete udder emptying without concern about productivity or increased new infection risk, (ii) rather an increase in milk yield, (iii) a lower fat content in the delivered milk, and (iii) good arguments concerning ethical production. There are ecological brands e.g., „KRAV" in Sweden that successfully sell good conscience to consumers. Typically these brands demand (i) that the calf suckles its mothers at least during colostrum period, (ii) that the cow must have the opportunity for isolation during calving, and (iii) that offspring and mother must have the possibility of close contact during the first days *pp* (KRAV 1995). Mostly this result in that the cow is kept in a calving box and stays there together with her calf during the first 5 days *pp*. Thereafter mother and offspring are separated and the usual dairy procedure takes place. Thus, the best intentions result in cruelty: *Peri*-natal death is an evolutionary provision to prevent a mother from making heavy lactation investment in a weak offspring. As closer to birth death occurs, the less the affiliation between mother and offspring. After 5 days, however, cow and calf recognize each other and prefer each other's company (Sambraus 1978). To separate them now means to imitate death. And both show deep grieve in their behaviour after such an event.

There might be one problem involved with ASP: When man and calf competed in stimulation during the same milking, the calf won (e.g., Knowles & Edwards 1983, Sandoval-Castro et al. 1999). However, only once an ASP applied in which the cows were always milked before suckling (Sandoval-Castro et al. 1999). Our own ASP experience (Table 1) is rather encouraging. If ever a man-made pre-stimulation would fail in an ASP, the olfactorial an/ or audio-visual and/or tactile presence of the own calf could help to achieve proper pre-milking ejection (Sambraus 1978). There is no argument, why such a procedure could not be combined with AMS.

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Table 1. Summary of research of author and co-workers on the cow-calf-model.

Objective	Used breed and number of animals	Number of recorded meals and type of recording	Publication
Ontogeny of suckling behaviour	Hereford, 8 Charolais, 1	84, video tape	E.g., Mayntz 1996
Pre-study of restricted access between cow and calf	Hereford, 13 Charolais, 1	26, video tape	Mayntz et al. submitted 2005
Control of ontogeny results	Polish Black & White, 5	83, video tape	Mayntz 1996
Pre-study on the effect of after-stimulation on fat composition	Hereford, 4 Swedish Red & White, 4	10, optical observation	Costa, et al. 1998
Effect of Pharmacologically Induced Changes in Milk Ejection on Suckling in *Bos taurus*	Hereford, 4	16, video tape	Mayntz and Costa 1998
Change of milk fat composition over a meal and between lactations	Hereford, 20 Swedish Red & White, 8	56, video tape	
Influence of milk fat content on teat preference by the suckling calf	Swedish Red & White, 10	30, video tape	
Control of effect of after-stimulation on fat composition	Hereford, 9	27, optical observation	Sederström, et al. 2002
Pressure in the teat cistern and the mouth of the calf during suckling.	Holstein Frisian, 3	4, video tape	E.g., Rasmussen and Mayntz 1998
Pre-study on the effect of after-stimulation on ejection and udder health	Polish Black & White, 14	280, optical observation	Sender and Mayntz submitted 2004
Influence of milk withdrawal, stable routines and separation from dam on suckling behaviour of calves	Hereford, 12	20, video tape	Mayntz et al., submitted 2005

Table 2. Summary of main differences between the milk harvest technique of the cow-calf-model and machine milking.

Calf	Milking Machine
Applies no pressure difference on a teat, which was judged empty.	Applies a pressure difference during machine-on-time. Machine-on-time can be adapted to the flow rate through the teat canal.
Waits for refilling of the cistern before the next emptying. Waiting about three times as long as emptying. A waiting teat is not stretched and under atmosphere. Smooth muscles can contract during waiting.	The teat is continuously stretched and under vacuum during machine-on-time. Vacuum is also used for different additional purposes, e.g., to keep the cluster on.
Applies pressure differences across the teat canal from 60 to 110 kPa with 2 to 2,4 Hz. A peak of a pressure difference last for 2-3 milliseconds and is followed by a minimum pressure differences between 0 and 10 kPa. The pressure difference consists of about 60 % vacuum and 40 % over-pressure.	Applies a constant pressure difference of about 40 to 50 kPa. The pressure difference consists of vacuum only.
Adopts bout length to amount of milk available in the cistern also during pre- and after-stimulation.	Concerning pre-stimulation you find everything on commercial farms☹I) careful farmers, performing as good as the calf, (ii) sometimes superior technique, and (iii) not careful milker.
Empties the cistern fast during ejection and completely during meal.	Empties the cistern during ejection. Cistern not empty after milk harvest.
Practises after-stimulation, no blockage of the udder-teat-passageway.	Builds up blockage of the udder-teat-passageway.
Uses saliva and endogen enzymes for teat cleaning and after-suckling disinfections.	Chemical disinfections mostly before and always after milking.
Harvests milk 4 to 6 times per day.	Harvests milk 1.8 to ca. 3 times per day.
Gives honest information to the cow's physiology about its need.	Gives contradictory information to the cow's physiology.