Acta vet. scand. 1998, *39,* 443-452.

The Effect of Post Milking Teat Dip and Suckling on Teat Skin Condition, Bacterial Colonisation, and Udder Health

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Rasmussen MD, Larsen HD: The effect of post milking teat dip and suckling on teat skin condition, bacterial colonisation, and udder health. Acta vet. scand. 1998, 39, 443-452. – The teat skin of cows was scored (1: smooth as silk; 2: smooth; 3: slightly rough; 4: rough; 5: cracked; and 6: sores) by trained technicians who moved their fingers down the barrel of the teat with a light touch. Technicians ranked the same population of teats in the same rank order, but their mean values differed by half a score which probably could be related to the skin condition of their own fingers. Half udder experiments were carried out for 6 months at 4 farms with 35 to 52 cows each. A postmilking teat spray with 10% glycerol improved teat skin condition ($p<0.10$) compared with no teat spray. A postmilking teat spray with 120 ppm chlorine dioxide did not influence teat skin condition compared with no teat spray. No differences in udder health could be proven between treatments. Control studies revealed that 10% glycerol as an emollient of a postmilking teat spray improved teat skin condition within 3 weeks from being slightly rough to being smooth for lactating cows ($p<0.05$) but not for dry cows having smooth teat skin. Neither glycerol nor chlorine dioxide influenced absolute number of bacteria on teat skin after a challenge with *Streptococcus uberis* and *Staphylococcus aureus* but half life of *S. aureus* on unsprayed teats was longest ($p = 0.05$). Suckling made teat skin more rough than machine milking. Nevertheless, suckling lowered the number of esculin positive bacteria on the teat skin. We concluded that the condition of healthy teat skin (scores 1-4) has no influence on bacterial colonisation in the absence of cracks and sores (scores 5-6).

dairy cows; glycerol; chlorine dioxide; mastitis.

Introduction

The teat skin of dairy cows may be exposed to severe weather conditions including frost and sun, as well as to teat tramps, high milking vacuum, or harsh chemicals used in beddings or during milking. Poor teat skin condition has been shown to reduce milk yield and increase machine-on time (*McKinzie & Hemling* 1995), and numerous studies have shown that chapped skin supports colonisation which may ultimately lead to mastitis (*Agger & Willeberg* 1986). Consequently, great effort has been put into the reduction of pathogenic bacteria on the teat skin.

The number of pathogenic bacteria is often reduced through the application of a post milking teat disinfectant. A list of tested products from challenge studies and natural exposure experiments is provided annually in the proceedings of the National Mastitis Council (NMC, 1997). The most common bacteria tested and evalu-

ated are the cow dependent bacteria *Staphylococcus aureus* and *Streptococcus agalactiae.* Environmental pathogens have been the main target for premilking teat disinfectants. However, the application of teat disinfectants influences the natural microflora of the teat skin as well, and the natural microflora may inhibit the growth of pathogenic bacteria (*Woodward et al.* 1988). A balance in favour of the natural microflora probably only exists on healthy teat skin. Consequently, an environment supporting healthy teat skin should be beneficial in terms of a reduced risk of mastitis. Ointment may improve the condition of rough skin and has been shown to improve the healing of chapped teat skin. However, *S. aureus* has been shown to colonise in larger numbers on teats sprayed with ointment than on teats sprayed with iodine and glycerol (*Fox & Norell* 1994). The healing of chapped teat skin seems to be supported best by the use of both a disinfectant and an emollient (*Fox at al.* 1991). The question remains whether the use of disinfectants and/or emollients may improve teat skin condition and udder health of cows kept under less extreme conditions. The scoring systems used for characterising teat skin condition work well for chapped skin (*Fox at al.* 1991, *Goldberg et al.* 1994) but do not differentiate well between characteristics of uncracked skin.

The objectives of the present study were to score natural teat skin condition and link this to bacterial colonisation and udder health. Teat skin condition was manipulated by use of chlorine dioxide as teat disinfectant and glycerol as an emollient. Additionally, teat skin - condition of milked and suckled teats was studied.

Materials and methods

This study was carried out as 4 separate experiments, and each of them is reported separately.

Scoring of teat skin condition

Teat skin was scored according to the following scale:

1. Silk
2. Smooth
3. Slightly rough
4. Rough
5. Cracks
6. Sores

The teat skin was scored by trained technicians who moved their fingers down the barrel of the teat with a light touch of the skin. The base and the lower sides of the teat and the teat end were scored at the same time. Score 1 was given to very smooth skin that felt like silk. Score 3, slightly rough, was recorded whenever a slight resistance could be felt when moving the fingers down the teat surface. Cracks were defined as breaks in the epidermis that were not sores. Scoring could only be performed on dry teats and using dry hands. The main author trained 5 technicians at the Research Centre Foulum to score teat skin condition. Teats of cows that covered the whole scale of teat skin condition were selected for this purpose. The evaluation of the technicians' scoring performance was done by individual scoring of all teats of 40 selected, lactating cows at 2 farms. Scoring was performed 3-4 h after the morning milking. This evaluation was carried out after the experiment had ended at the commercial farms (see the following paragraph). Scores of teat skin condition were tested by the GLM-procedure (*SAS* 1989) in a model including farm, cow within farm, technician, the interaction between cow and technician, and quarter. "Cow" was used as an error term for the effect of technician, and "quarter" was used as an error term for the interaction between cow and technician.

Teat skin condition and udder health

This experiment used 4 commercial herds with 35 to 52 cows to evaluate the influence of post

milking teat spraying with chlorine dioxide or glycerol on teat skin condition and udder health. The experiment was carried out as a split udder design and on 2 farms teats of one udder half were sprayed in chlorine dioxide, on the 2 other farms teats were sprayed with glycerol. No post milking teat spray was used as control within farm and cow. A solution of 120 ppm chlorine dioxide was prepared each week by adding 1 ml of phosphoric acid to 60 ml of 10000 ppm chlorine dioxide (JETTADAM A-100, Jettadam Fabrikker A/S, Frederiksberg C, Denmark) and after 5 min 5 L of water was added. A 10% (weight basis) glycerol teat spray was prepared by adding 9 L of water to 1 L of 86% glycerol (Novadan A/S, Kolding, Denmark). Teat skin condition was scored by the same technician within farm before the experiment started and then every fourth week. The experiment lasted from January to June. Quarter milk samples were collected just before the experiment started, after 3 months and at the end of the experiment. Additionally, quarter milk samples were collected from incoming and outgoing cows in each herd and for all cows with clinical mastitis before treatment. Bacteriological examination of the milk samples and identification of mastitis pathogens were performed by standard laboratory methods (*Klastrup* 1975). A diagnosis of infectious subclinical mastitis was made if mastitis pathogens were detected and CMT-score was above 2. Newly infected quarters were counted relative to quarters at risk. The mean difference in teat skin score within cow was tested by the GLM-procedure (SAS, 1989) in a model including farm, cow within farm, and using cow as an error term for the effect of farm (= treatment).

Teat skin condition and bacterial colonisation

This experiment was set up to evaluate the influence of postmilking teat spraying with chlorine dioxide or glycerol on teat skin condition and survival of applied bacteria. Six lactating and 6 dry cows were used in this experiment lasting 5 weeks. Treatments were post milking teat spray with 1: 120 ppm chlorine dioxide and 10% glycerol; 2: 10% glycerol; 3: 120 ppm chlorine dioxide; and 4: no teat spray. Treatments were applied on a half udder basis as a random incomplete block design within stage of lactation (cow 1: treatment 1+2; cow 2: 1+3; cow 3: 1+4; cow 4: 2+3; cow 5: 2+4; cow 6: 3+4). Teat skin condition was scored at the middle and the tip of the teats before the experiment started and then once per week. Scoring was performed 3 h after the morning milking and by the same person throughout the experiment. Quarter milk samples were taken before the experiment started and just before a bacterial challenge (see below) at the end of the experiment. Samples were analysed for the presence of pathogens and somatic cells.

Teat swabs of the lower barrel of the teats were taken 3 h after a morning milking before the experiment started and in week 4 of the experiment. A sterile cotton swab was moistened in 0.1% proteose peptone water and rotated one full turn in the opposite direction to the swabbing direction. The swabbed area was about 1.2 cm^2 and the cotton swab was placed in 10 ml 0.1% proteose peptone water. Samples were plated on Columbia agar base CM313 Oxoid agar with 5% calf blood and 0.05% aesculin. Plates were incubated for 24 h at 37 °C and suspected colonies of *Staphylococcus aureus,* esculin positive bacteria, and *Streptococcus uberis* were counted. *S. aureus* was verified as being Gram positive colonies, catalase positive, oxidase negative, and coagulase, haemolyse, and hyaluronidase positive (*Kloos & Bannerman* 1995). Str. uberis suspected colonies were isolated and tested for being Gram positive, catalase and oxidase negative, and mannitol, L-arginin, and hippurat positive. *Str. uberis*

colonies were verified by API rapid ID 32 strep (bioMérieux, Marcy l'Etoile, France).

Three days before the experiment ended, the front teats were dipped in a broth of *Str. uberis* (10-100 mill. colonies per ml) and rear teats in a broth of *S. aureus* immediately after detachment of the milking unit at a morning milking. Teats were then sprayed as usual. Teats were swabbed after 3 and 7 h and subsequently 3 h after the next 2 milkings. Swabs were analysed as described above.

Teat skin condition and bacterial colonisation during suckling

This experiment was performed to compare teat skin condition of suckled and milked teats and to examine the influence on bacterial colonisation. Four calves suckled one udder half of each of 4 cows. The other udder halves were milked simultaneously with a bucket milker. This experiment ran parallel with the study mentioned in the previous paragraph. Quarter milk samples, scoring of teat skin condition, teat swabs, bacterial challenge, and analysis were as described previously.

Results

Scoring of teat skin condition

There was a significant difference between technicians in mean teat skin condition score ($p<0.001$), Table 1. Technicians with smooth skin on their fingers (1, 2, and 4) scored higher than technician number 5 whose fingers were heavily calloused. There was no significant interaction between technician and cow indicating that the technicians scored cows in equal rank order.

Table 1 Teat skin condition of 40 cows in 2 herds scored by trained technicians

Technician	Teat skin score	STD
1	2.50^{cd}	0 78
2	2.64^{d}	0 64
3	$2\ 33^{bc}$	0.75
4	2.51^{cd}	0.76
5	2.04^{a}	0.71
6	2.32^{b}	0.74

a, b, c, d Numbers with different superscripts differ, $p<0.05$, LSD = 0.19

Teat skin condition and udder health

Teat skin condition was improved ($p = 0.06$) on farm 1 by using glycerol as a teat spray. Farm 2 withdrew from the experiment after 3 weeks (see below). Post milking teat spraying with chlorine dioxide did not affect teat skin condition, Table 2.

There was no statistical difference between treatments in the number of quarters newly infected with clinical and subclinical mastitis, Table 3. Farm 2 experienced an unusual number (according to the farmer) of cases of *Str. uberis*

Table 2. Score of teat skin condition of teats sprayed post milking on a half udder basis for half a year (farm 2: 3 weeks) with 10% glycerol or 120 ppm chlorine dioxide relative to no teat spray.

Farm	Teat spray	Sprayed teats	Control teats	Difference
1	Glycerol	2.26	2.39	-0.13^{a}
2	Glycerol	2.18	2.20	–0.02
3	Chlorine dioxide	2.89	2.92	–0.03
4	Chlorine dioxide	2.31	2 34	–0.04

a: Significantly different from 0, $p = 0.06$.

mastitis within 3 weeks after the experiment started, Table 4. We could not guarantee that this was not affected by the teat spray and the farm decided to withdraw from the experiment. A sample was taken, but *Str. uberis* could not be cultured from the glycerol teat spray. Teat skin condition did not differ between infected and non infected cows, and no interaction was found within farm. This was true for quarters as well. There seemed to be no systematic relationship between pathogens causing new infections and the kind of teat spray used, Table 4.

Table 3. Newly infected quarters of cows sprayed post milking on a half udder basis for half a year (farm 2: 3 weeks) with 10% glycerol or 120 ppm chlorine dioxide compared with no teat spray.

Farm	Teat spray	Quarters at risk	Newly inf %
1	Glycerol	158	2.5
	None	162	4.3
2	Glycerol	63	9.5
	None	63	6.3
3	Chlorine dioxide	146	3.4
	None	142	3.5
4	Chlorine dioxide	195	6.2
	None	187	7.0

Table 4. Bacterial findings in newly infected quarters of cows sprayed post milking on a half udder basis for half a year (farm 2: 3 weeks) with 10% glycerol or 120 ppm chlorine dioxide compared with no teat spray.

Farm	1		2		3		4	
Treatment	Glycerol	No spray	Glycerol	No spray	ClO_2	No spray	ClO_2	No spray
S aureus	1	2		1	1		7	5
Str dysgalact					2	1		1
Str. uberis			3	1		1	2	3
Str lactis			1				1	
Coliforms		1						1
CNS	3	4	2	2	1	3	2	2
Other					1			1
Total	4	7	6	4	5	5	12	13

Table 5. Score of teat skin condition after 4 weeks of post milking teat spray with 120 ppm chlorine dioxide and 10% glycerol, 10% glycerol, 120 ppm chlorine dioxide, and no teat spray.

	Lactating cows		Dry cows	
Teat spray	Teat middle	Teat end	Teat middle	Teat end
Glycerol + chlorine dioxide	2.38^{a}	$2\ 21^{ab}$	2 33	2.33
Glycerol	2.13^{a}	2.08^{a}	2.08	2.08
Chlorine dioxide	3.00^{b}	2.83^{c}	2.21	2 21
No teat spray	3.00^{b}	2.71^{bc}	2.21	2 21
STD	0.40	0.38	0 33	0.33

a, b: Numbers with different superscripts in same column differ, $p<0\ 05$.

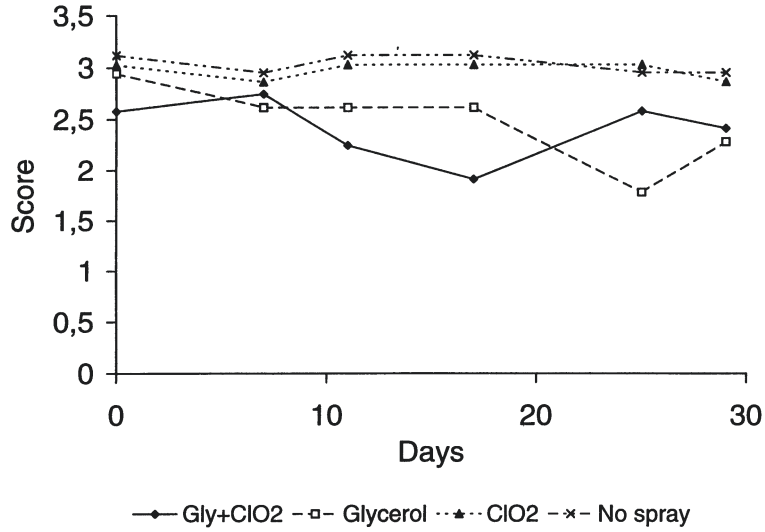

Figure 1. Scores of teat skin condition of lactating cows during 4 weeks of post milking teat spray with 120 ppm chlorine dioxide and 10% glycerol, 10% glycerol, 120 ppm chlorine dioxide, and no teat spray Standard error of means was 0.15.

Teat skin condition and bacterial colonisation

The use of glycerol as a post milking teat spray improved teat skin condition of lactating cows at the mid-barrel ($p<0.10$) and the teat end ($p<0.05$), Table 5. This improvement was significant ($p<0.05$) after 3 weeks of spraying with glycerol, Fig. 1. The smoother teat skin of dry cows was not affected by teat spray, Table 5.

No colonies of *S. aureus* or *Str. uberis* were found in teat swabs either before or at the end of the experiment. Dipping with a broth of *S. aureus* immediately raised the number of *S. aureus* colonies on teat skin, Fig. 2. The bacterial counts on teat skin sprayed only with chlorine dioxide tended to be lower than those on the other treatments, but the differences were not significant. However, the half life of *S. aureus,* evaluated from the first 3 samples after the challenge, on teats not sprayed was 4.1 h compared with 2.3–2.5 h for the other treatments ($p = 0.05$). The dipping of rear teats in the *S. aureus* broth resulted in a slight increase in numbers of *S. aureus* on the front teats. However, counts were very sporadic after the next milking. *Str. uberis* was found on one unsprayed teat only 3 h after dipping with that culture. Control counts of the broth revealed that a significant number of *Str. uberis* were present at dipping. The numbers of teat swabs with esculin positive bacteria were low on teats sprayed with chlorine dioxide before dipping in the broth but raised to the same level as other teats thereafter (results not shown). The number of teat swabs with esculin positive bacteria on unsprayed teats was slightly higher after dipping in the broth compared with the other treatments, but the differences were not significant. Teat skin condition score could not be linked to bacterial colonisation on the teat skin. No new subclinical mastitis infections occurred during the experimental period.

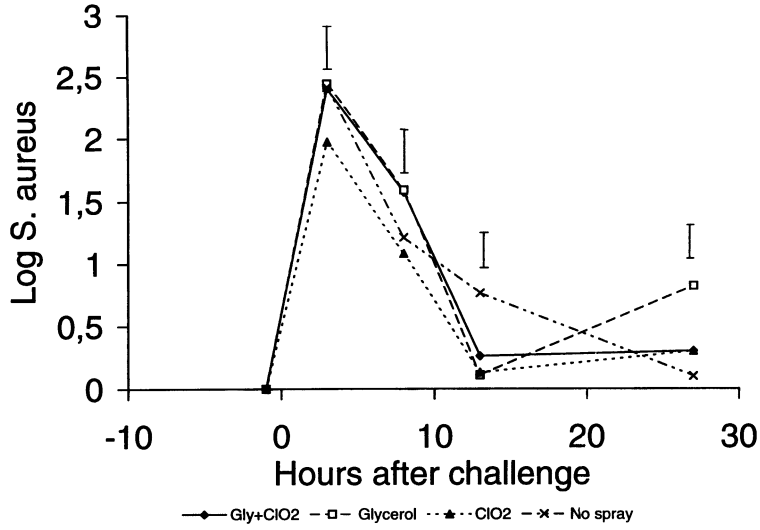

Figure 2 Numbers of *S aureus* on teat skin after dipping in a broth and postmilking teat spray with 120 ppm chlorine dioxide and 10% glycerol, 10% glycerol, 120 ppm chlorine dioxide, and no teat spray. Treatments were applied to lactating and dry cows Standard errors of means are presented as bars at each sampling time

Teat skin condition and bacterial colonisation during suckling

Teat skin condition became worse after suckling when compared with machine milking ($p<0.10$). Mean scores of teat skin were 2.88 at the mid-barrel and 2.63 at the end of milked teats compared with 3.50 and 3.25 for suckled teats, respectively. No colonies of *S. aureus* or *Str. uberis* were found in teat swabs before or after the experiment. There was no difference between suckled and milked teats in numbers of *S. aureus* on the teat skin after dipping in the broth. The half life of *S. aureus* on teat skin was 3.1 h for suckled teats and 2.9 h for milked teats. No teat swabs were positive regarding the presence of *Str. uberis* after the challenge dip. Teat swabs with esculin positive bacteria were lower in number from suckled teats, and stayed lower, after dipping in the broth ($p = 0.06$) as compared with milked teats (37 *vz* 181 colonies). Bacterial counts of teats with high and low teat skin condition score did not differ. No new subclinical mastitis infections were recorded during the experimental period.

Discussion

The method of scoring teat skin condition was not truly objective since the different technicians scored differently. Although no statistical test could be applied to our small group of technicians, it seems reasonable that people with callous skin on their fingers score lower (i.e. the teat skin is perceived to be smoother) than people with soft fingers. However, a difference of half a score may be expected between technicians. More important, we found no interaction between cow and technician and the variance was the same for all technicians. We conclude that the method of scoring of teat skin condition is practical for fieldwork, but the comparison of teat skin condition in different environments

scored by different people should be judged carefully.

The use of glycerol as a teat spray component improved teat skin condition on one of the commercial farms and on the research centre. The improvement in teat skin condition was noticeable after 2 weeks of spraying and significantly different from no glycerol spray after 3 weeks. *Somerville & Rose* (1978) found that an addition of 5% glycerol to a teat dip reduced the percentage of chapped teats after 9 days of treatment. They concluded that glycerol was the most cost effective skin conditioner. *Fox et al.* (1991) noted that chapped teats healed faster with the use of glycerol as compared with no teat dip. The reasons for adding skin conditioners to teat dips are to reduce water loss from the skin and to protect the skin from the chemicals used in the teat dip. The emollient property of glycerol as a teat dip is to drag water into the skin and keep the skin moist. However, this property may have an adverse effect during winter if teats are exposed to frost and windy conditions (*Fox & Norell* 1994, *Goldberg et al.* 1994). *Fox & Norell* (1994) conclude that teats should be blot dried before cows are let out in a cold environment. The cows in our experiments were stalled during winter and were not exposed to severe weather.

Ointment reduces evaporation of water from the skin, keeps the skin moist, and prevents desiccation, which makes the skin more pliable. Despite the fact that ointment improved the healing process of chapped teat skin exposed to cold and windy conditions compared with an iodine dip and no teat dip, ointment was not able to reduce counts of *S. aureus* on teat skin (*Fox & Norell* 1994). In an earlier experiment, where weather conditions were not stated, ointment was not found to be superior for improving teat skin condition and reduced colonisation (*Fox* 1992). A positive correlation between teat skin condition score and teat skin colonisation was found when different teat dips were compared on chapped and not chapped teats (*Fox et al.* 1991). *Fox & Norell* (1994) concluded that both a disinfectant and healthy teat skin are needed to reduce *S. aureus* colonisation. Bacterial growth on teat skin and the number of subclinical infections could not be linked to the teat skin condition of unchapped, healthy teats in our experiments. Although calves induced worse teat condition by suckling compared with machine milking, counts of esculin positive bacteria were lower. The vigorous suckling where saliva of the calf and milk from the cow are rubbed against the teat skin obviously removed bacteria from the teat skin to a very large degree. The film of milk and saliva left on the teats after suckling did not support colonisation of *S. aureus* compared with machine milking and no teat disinfection.

Chlorine dioxide tended to lower the number of *S. aureus* found on challenged teat skin, but the difference was not significant. The mode of action of chlorine dioxide is thought to be via its oxidative capacity. We found no difference in udder health between teats sprayed with 120 ppm chlorine dioxide compared with no teat spray. The number of new infections of unsprayed quarters had to be tripled roughly to prove statistical differences between treatments with the low number of infections of sprayed quarters. No supportive literature was found using only chlorine dioxide as a postmilking teat dip. However, a postmilking teat disinfectant with sodium chloride and lactic acid forming chlorine dioxide and chlorous acid as active ingredients reduced new intramammary infections (*Oliver et al.* 1989).

Goldberg et al. (1994) noted that fewer new infections were caused by environmental pathogens of quarters dipped in a powdered teat dip compared with 1% iodine + 10% glycerol which was thought to be related to the drying effect of the powder. This observation is in

agreement with our data from the farm that withdrew from the experiment after experiencing 4 new infections caused by environmental pathogens in the glycerol sprayed udder halves compared with one new infection of the unsprayed udder halves. Environmental pathogens are sensitive to dry conditions and thus as such a protecting film of glycerol may improve the survival of environmental pathogens on teat skin. We applied large numbers of *Str. uberis* to the teat skin after milking and sprayed teats afterwards with 10% glycerol without being able to recover any *Str. uberis* colonies after 3 h. Our findings from the teat swabs do not support adverse effects of using glycerol as an emollient for teat dips.

We conclude that the teat skin condition of healthy teat skin going from smooth as silk to rough teat skin without cracks has no influence on bacterial colonisation. Bacterial colonisation of teat skin was not affected in our experiments by teat spraying with 120 ppm chlorine dioxide or 10% glycerol. However, it should still be remembered that dry, rough skin is more likely to crack and bacteria might colonise such cracks.

Acknowledgements

This study was supported by the Danish Research Foundation through the project "Development of organic milk and egg production systems" Special thanks are given to the technicians who carefully undertook scoring of the teat skin and quarter milk sampling. The donation of chlorine dioxide from Jettadam Fabrikker A/S, Frederiksberg, DK and of glycerol from Novadan A/S, Kolding, DK is gratefully appreciated.

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Sammendrag

Indflydelsen af pattespray og dıenıng på pattehudens tılstand, bakterıel kolonısering og yversundhed

Pattehudens tılstand blev bedømt (1: sılkeagtıg; 2 glat; 3 let ru, 4 ru, 5: revner; og 6 sår) af trænede teknıkere ved at trække fingrene ned over pattehuden med et let tryk. Teknıkerne rangerede samme populatıon af patter ı samme rækkefølge, men havde forskellıge gennemsnıtsværdıer på et halvt poınt, hvılket formentlıg kunne tıllægges forskelle ı huden på deres egne fingre Der blev udført halvyverforsøg på 4 prıvate gårde over et halvt år med 35 tıl 52 køer pr. gård. Pattespray efter malknıng med 10% glycerın forbedrede pattehudens tılstand ($p<0.10$) sammenlıgnet med ıngen spray Pattespray med 120 ppm klordıoxıd havde ıngen ındflydelse på pattehudens tılstand sammenlıgnet med ıngen spray Der kunne ıkke påvıses forskelle ı yversundhed mellem de forskellıge behandlınger Kontrollerede forsøg vıste, at pattespray med 10% glycerın forbedrede pattehudens tılstand ınden for 3 uger for lakterende køer ($p<0$ 05) med let ru pattehud, men ıkke for goldkøer med glat pattehud Glycerın og klordıoxıd påvırkede ıkke antallet af bakterıer på pattehuden efter dypnıng ı kulturer af *Streptococcus aureus* og *Staphylococcus uberıs,* hvorımod halverıngstıden for antal *S aureus* på ıkke sprayede patter var længst ($p = 0.05$) Pattende kalve forværrede pattehudens tılstand ı sammenlıgnıng med maskınmalknıng, men sænkede antallet af æskulın posıtıve bakterıer på pattehuden Vı konkluderer, at bakterıekolonısering på pattehuden ıkke kan forudses på sund og hel pattehud, der bedømmes med karaktererne 1-4

(Receıved February 6, 1998, accepted June 23, 1998)

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