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Brief Communication

The Electrical Conductivity of Bovine Milk in Mastitis Diagnosis

The electrical conductivity (EC) of milk is mainly a function of the electrolyte concentration in the milk and therefore raised in mastitis. The present investigation was aimed at elaborating, if possible, a diagnostic model for screening purposes based on EC determinations and consistent with the diagnostic procedures and interpretations commonly used in laboratory milk diagnosis in the Nordic countries (*Klastrup* 1975). According to this diagnosis (here called reference diagnosis) cell numbers above 300,000/ml (cell count or the corresponding CMT-score) in foremilk quarter samples during the main part of the lactation period and significantly above the lowest value on within-udder comparison during late lactation are considered indicative of mastitis and bacteriological examinations are made when called for.

Most of the investigation was carried out in a large Swedish dairy farm and included 23 pregnant cows yielding 6–32 kg of milk/day. Eighty-one quarters were non-mastitic, and 11 quarters mastitic of which 6 and 3 cases had infection of Staphylococcus aureus and coagulase-negative staphylococci, respectively, and 2 cases were without isolated pathogens (reference diagnosis). Samples of foremilk, mainmilk (from the beginning of the mainmilk flow) and stripmilk were collected at 4 consecutive milkings starting with an evening milking. EC was measured with a laboratory equipment (CDM 80, CDC 104, Radiometer A/S, Copenhagen) at 25°C (waterbath) as soon as possible after the samplings. The sample collections and measurements were repeated with 11 of the cows 1 and 2 weeks later. EC conditions were also studied in some cows belonging to other herds in relation to herd, calving, oestrus, transition to pasture, and a disease other than mastitis (food-poisoning).

Table 1 refers to the main part of the investigation and summarizes some data on the examined cows and quarters and the obtained EC values. The cows are divided into 2 yield groups (vide below). Table 2 presents the range of the EC values of the same cows. The single EC values were fairly evenly distributed between the extremes. The trial-

Table 1. Electrical conductivity (EC) of milk, 23 cows, 6–32 kg of milk/day. Number of cows, quarters and EC values divided according to yield. Diagnosis refers to the reference procedures and figures in brackets to the 11 cows examined in 3 four-milking series 1 week apart.

Cows	Daily yield, kg	Non-mastitic quarters	Mastitic quarters	EC values
15 (4)	14–32	53 (14)	7 (2)	1104
8 (7)	6–13	28 (24)	4 (4)	1056
23 (11)	6–32	81 (38)	11 (6)	2160

Table 2. Electrical conductivity (EC) of milk, 23 cows, 81 non-mastitic and 11 subclinical mastitic quarters, 4 consecutive milkings/cow, 3 milk portions/milking, range of measurements.

Milk portion	EC, mS/cm Not mastitis	Mastitis
Foremilk	4.83–9.01	4.88–9.86
Mainmilk	4.46–7.27	4.83–7.03
Stripmilk	4.00–7.38	4.52–7.91

and-error method was used in the attempts to translate the EC values into diagnostic terms. EC differences within udder and milking of the higher-yielding cow group not exceeding 0.50 mS/cm in the mainmilk or 0.80 mS/cm in the stripmilk (separately evaluated) at two, or more, consecutive milkings proved to be indications of not mastitis in consistency with the reference diagnosis. This was valid without exception for the 53 non-mastitic quarters (reference diagnosis) studied in 1 or 3 four-milking series and also in an additional series comprising 16 non-mastitic quarters and 10 consecutive milkings. – By EC difference is meant the difference between a quarter to be tested and the lowest EC within udder, milking and milk portion.

The corresponding EC differences of 5 of the 7 mastitic quarters (reference diagnosis) in the higher-yielding cow group (one four-milking series) were above the proposed borderline values within udder, milking and milk portion on at least two consecutive milking occasions. This result was considered to indicate the EC diagnosis of mastitis. One of the remaining mastitic quarters (Staphylococcus aureus; cow yield 15 kg/day) was moderately enlarged and fibrotic, the other one (coagulase-negative staphylococci; cow yield 18 kg/day) highly atrophic. Quarter yields were considerably lower than those of the contralateral quarters. In both cases 3 four-milking series were performed. EC diagnosis of mastitis was expected but became not mastitis in 1 of the quarters (the fibrotic one) in the mainmilk portion of the first milking series. It is established practice when the laboratory diagnosis is contrary to expectation, or else doubtful, to repeat the laboratory examination and, if the laboratory results are conflicting, to give the diagnosis of mastitis priority to the diagnosis of not mastitis. The repetitions in this specific case, i. e. the second and third milking series, indicated not mastitis and mastitis, respectively. Following practice, the final EC diagnosis would thus be mastitis. EC diagnosis of the same quarter in the stripmilk portion of the first milking series and of the other quarter (the atrophic one) in both milk portions of the same series was mastitis. Further examinations were not required but were performed as planned. The diagnosis of not mastitis and mastitis alternated in the second and third milking series.

The applied diagnostic model thus resulted in EC diagnoses in consistency with the reference diagnosis in all quarters so far dealt with (other models tried, using foremilk, absolute EC values and/or EC values from single measurements as integrated components, were clearly inferior). Mainmilk and stripmilk were diagnostically equivalent with respect both to non-mastitic and to mastitic quarters. In practice, mainmilk may be preferred in herds where automated sampling can be arranged for and stripmilk in herds with manual sampling.

The proposed diagnostic model did not function in the 8 cows yielding 6–13 kg of milk/day, 7 of which were examined in 3 four-milking series. EC in the mastitic quarters within udder, milking and milk portion was often not highest, sometimes even lowest. The lower-yielding cows were therefore considered not suitable for EC diagnosis.

EC comparison between two large herds, which seemingly were very similar with respect to animals, yield, management and udder health, revealed an EC difference between the herds of 0.72 mS/cm, in relative terms 100:112 (means of cow means, 3 milk portions). The difference should have been the sum effect of minor factors, each of which could not be dissected out and evaluated. The differential EC values within

udder, milking and milk portion were, however, very similar in both herds. EC values after calving, around oestrus and in connection with the transition from indoor-feeding to pasture could be irregular and simulate mastitis. This is in contrast to earlier Swedish experience (*Björkenfeldt et al.* 1984), according to which no significant EC alterations appeared during the mentioned circumstances. The same reference diagnosis was used as in the present investigation, but the criteria of the EC diagnosis of not mastitis and mastitis were less rigorous. Considerable discrepancies were observed in a large herd between EC diagnosis and reference diagnosis during an outbreak of food-poisoning due to silage of poor hygienic quality and for some time afterwards as well. EC conditions are to be evaluated with precaution in situations of physiological or other instability.

Many reports on EC and EC diagnosis in milk have been published since the 1940s, but no diagnostic model adapted to the demands in the Nordic countries has so far been proposed. The present model is open to critisism. Further studies are certainly needed. Anyhow, the results support the view held by most investigators, viz. that EC diagnosis may well become instrumental in practical mastitis control when more has been learnt about its possibilities and limitations. It may be able to compete favourably with cell count and other screening methods available today and to be adjusted to the varying diagnostic requirements in mastitis control in different parts of the world.

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