Measuring teat dimensions using image analysis

Messung der Zitze Dimensionen anhand der Bildanalyse

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Abstract

The interaction between teat and teatcup liner can strongly affect the milking characteristics and udder health. Therefore teat morphology is an important parameter in choosing the most appropriate liner. Nevertheless, teat morphology is rarely considered in choosing a teatcup liner. Gathering information on teat morphology on large scale with current techniques is time consuming, subjective and not always accurate. However, the ability to measure teat shape parameters in an easy way and on large scale has many applications. This study presents a new vision based measuring system that uses a camera to obtain a 2D image of the teat and image processing analyses to determine teat length and diameters. The technique is proven to be accurate (error less than 6%), repeatable and reproducible for both teat length and diameters.

Keywords: dairy cows, teat dimensions, teatcup liners, measuring technique, image analysis

Zusammenfassung

Die Interaktion zwischen Zitze und Zitzengummi kann die Melkeigenschaften und die Eutergesundheit stark beeinflussen. Folglich ist die Zitzenmorphologie ein wichtiger Parameter bei der Auswahl des geeigneten Zitzengummis. Dennoch findet die Zitzenform zu wenig Beachtung bei der Auswahl des Zitzengummis. Informationen über die Zitzenmorphologie auf umfangreichen Skalen mit gegenwärtigen Techniken zu erfassen ist Zeit raubend, nicht immer genau und oftmals sehr subjektiv. Daher bietet die Möglichkeit der automatischen Erfassung in umfangreichen Skalen viele Anwendungsfelder. Diese Studie zeigt ein neues Messsystem welches 2D Bilder der Zitze und Bildnalyseverarbeitung nutzt um Zitzenlänge und – durchmesser zu bestimmen. Die Technik ist genau (Fehler kleiner 6%) im Punkt Widerholbarkeit und Reproduzierbarkeit für die Parameter Zitzenlänge und -durchmesser.

Schlüsselwörter: Milchkuh, Zitzenmaße, Zitzengummi, Messtechnik, Bildanalyse

Introduction

The teat is a very important organ in the defence against mastitis. Nearly all intramammary infections (IMI's) occur as a result of pathogens gaining entry to the mammary gland through the teat canal (Chrystal et al. 1999). The milking machine is directly and indirectly involved in about 6% to 20% of the overall new IMI's. Direct effects consist of bacterial transport, impacts and cross-contaminations while indirect effects include the impairment of the teat condition, making the teat more susceptible (Mein et al. 2004). It is obvious that these direct and indirect effects should be prevented as much as possible. The liner design is proven to play a very important role in the occurrence of these effects (Gleeson et al. 2004). Furthermore, previous studies have shown that liner design usually has a greater influence on milking characteristics than any other machine factor (Brandsman 1968, Mein et al. 2003). A good choice of liner is therefore important for good udder health as well as for good milking performance. Because of the interaction between teat and teatcup liner, teat morphology is an important parameter in choosing the most suitable liner for a herd. However, the selection of a teatcup liner for a herd is currently based on a 'trial and error' basis (de Koning et al. 2003). Due to the large number of available liner types and given the large variation in teat dimensions between herds, between cows of the same herd and between teats of the same cow, choosing the most appropriate liner for a herd is not without difficulties. In practice, it is regularly observed that teatcup liners are not adjusted to the herd. Information on specific teat dimensions will be a first step towards better based teatcup liner choice.

State of the art: measuring methods

Visual scoring is up till now the general method to determine teat dimensions. Although subjective, it is a very fast and widespread technique that can be used on a large scale. In practice usually only teat length is scored and different scoring scales are used in different countries. Most countries use a linear scale from 1 to 9 or from 0 to 50. Nevertheless, teat length is one of the 18 standard traits used in the international classification system introduced by the World Holstein-Friesian Federation (WHFF) to provide uniform and standardised information regarding the transmitting abilities of bulls (WHFF 2005). In some countries additional traits are scored. For example, in Denmark teat diameter is scored as well (van Drie 2007). For research purposes, teat size is sometimes scored as a combination of teat length and circumference (Sapp et al. 2004). To obtain more objective and accurate results, calipers and measuring tapes are used to determine teat length and diameters (Hickman 1964, Blake & McDaniel 1979, Lin et al. 1987, Tilki et al. 2005). Another frequently used tool for measuring teat length is a transparant open-ended tube with a graduated scale and a diameter of 30 or 45 mm. The tube is placed over the teat and the length is noted from the scale (Hamann et al. 1993, Hansen 2002, Neijenhuis

2004, Gleeson et al. 2005). Here, the teat base is the point where the diameter of the tube equals that of the teat.

For measuring changes in teat end thickness, Hamann & Mein (1988) described the use of the cutimeter, a device that is normally used to measure skin thickness of cattle to check their reactions for tuberculosis tests. The cutimeter consists of two parallel jaw plates, each with a surface area of 400 mm^2, connected to a spring and a callibrated scale. The cutimeter is placed around the teat and a pressure of 20 – 25 kPa is applied on the teat. Although the cutimeter technique has good accuracy and repeatability, the measurements may be influenced by the absolute diameter of the teat. A modified version of the cutimeter was developed: an electronic caliper device. A pressure sensor connected to one of the jaws measures the pressure between the teat and the jaws at incremental steps of 0.5 mm closure of the jaws. Since the recordings start when the pressure between the jaws and the teat is 0.125 kPa, the first reading is a measurement of the diameter of the teat apex (Hamann et al. 1988). Another extensively employed method for measuring teat morphology and teat tissue changes is ultrasonography (Gleeson et al. 2004, Neijenhuis 2004, Paulrud et al. 2005). To prevent deformation of the teat image, direct contact between the probe and the teat is avoided by placing the teat in a latex bag filled with warm water. The variables recorded from the ultrasonographic image with a software program are teat canal length, teat cistern width, teat wall thickness and teat diameter. With this method, teat dimensions are measured accurately but an experienced observer and substantial measuring time are needed.

It can be concluded that, although the existing methods all have advantages and disadvantages, until now no objective, accurate and fast method capable of gathering data on a large scale is available. However, such a method is a prerequisite for better selection of teatcup liners or more specific breeding to more uniform teat dimensions. Digital image processing technology offers new opportunities and has already been tested to measure udder morphology in dairy ewes (Marie-Etancelin et al. 2002).

Vision based measuring technique

At the Institute for Agricultural and Fisheries Research (ILVO) in Flanders, Belgium, a vision based measuring system has been developed. Certain requisites must be met for a vision based approach to be successful. For accurate and standardised analysis, light conditions and position of the object to the camera need to be kept constant. Other important factors that must be taken into account are robustness, weight and ergonomic aspects.

The measuring device consists of an aluminium profile through which the teats are, each separately, inserted through a round opening of 50 mm diameter. To obtain 2D images of the teats, an AVT Guppy F-046B camera with a 25 mm lens is mounted on the other end of the profile. At the back of the profile a LED source is placed for illumination. It serves as background light to acquire high contrast contours of the teats, which is essential for accurate measurements (Figure 1). The camera and the LED-background are triggered simultaneously by a push button on the aluminium housing. After a picture is taken, it is automatically transcribed to a tablet PC. The function of the tablet PC is tripple: it is used for controlling the settings of the camera, for automatic storing of the images and for visual control of the images by a second person. The latter is needed to make sure the images meet the requirements necessary for further image processing. For good image analysis the subject needs to be isolated from the surroundings. If this is not the case, a new image has to be made. The resolution of the images is 0.189 mm/pixel.

The analysis is performed with an image processing algorithm in Halcon 8.0. The software calculates the length of the teat and a predefined number of diameters at relative lengths of the teat base (Figure 2). A correction factor is added to teat length and diameter measurements for errors that are made if the teat is under an angle in the transverse plane.

Teats positioned straight through the opening, give almost no inaccuracies. For teats that make an angle of maximum 30° towards the camera the error on the teat length is less than 5%. For teat diameters the maximum error of the barrel under that angle is 6%. The measuring technique is proven to be repeatable and reproducible for teat length as well as teat diameter measurements. The majority of variation is present at the cow and quarter level rather than at the observation level, indicating variation between repeated measurements is small.

Future perspectives

The newly developed vision based measuring tool, measuring teats in a fast, objective and accurate way, will make it possible to identify and investigate factors influencing teat dimensions. In addition, since information of the whole teat is available, liner performance can be evaluated in relation to teat dimensions by assessing udder health and milking characteristics. The information generated using the tool will enable better selection of teatcup liners adapted to herd on the short term. Automatic milking systems should even be able to chose the liner best fitting for a certain teat. On a longer term the information will lead to more uniform teat dimensions within a herd through selective breeding, what will simplify the liner choice. Better liner selection will result in better teat condition, decreasing the incidence of intramammary infections and thereby improving the quality and the quantity of the milk yield.

Conclusion

Various methods have been described to measure teat dimensions. However, these methods have a poor objectivity, give only little information or are only practical in experimental conditions. The use of image analysis permits a faster, more objective and accurate measurement of teat shape parameters. A new objective, accurate, repeatable and reproducible 2D vision based measuring method is presented. Further experiments will be conducted to get more information on factors influencing teat dimensions and, by assessing udder health and milking characteristics, on the relationship between them and liner performance.

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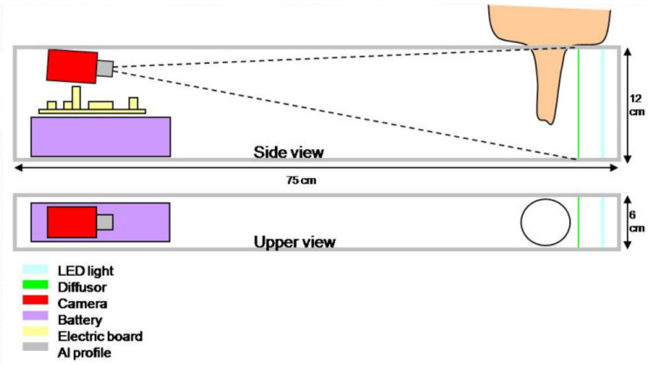

Figure 1: Vision based measuring device for measuring teat dimensions.

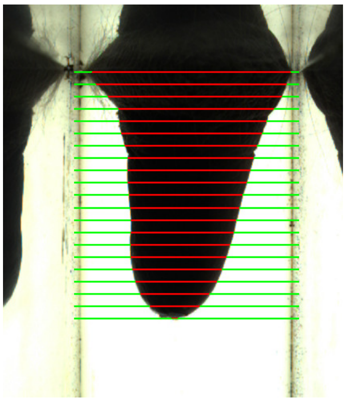
Figure 2: Image of a teat taken with the teat measuring device with indication of the different diameters calculated.