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Ultrasound evaluation of the mammary gland tissue structure in preparturient heifers vs. performance of first calvers

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Abstract

To determine the development of secretory tissue of the mammary gland and to avoid the use of invasive methods, tissue structure of the mammary gland was examined in vivo with Aloka SSD-500 ultrasound device (Aloka Co., Ltd., Japan). The ultrasound images were binarized and brightness level was determined on a grey scale of 0 to 255. The image brightness scale of 128 (lower threshold) to 255 (upper threshold) was applied. Pixels with brightness values of 0 to 127 were assigned to the adipose tissue, and pixels with brightness values of 128 to 255 were assigned to the secretory tissue of udder quarter. Then, percentage of bright image area was calculated in a predetermined image area. The results were recorded with regard to the area of the predetermined ultrasound image portion, the grey area and the percentage of grey area, and was output in the results file. Highly significant correlations were found between the percentage of secretory tissue in the mammary gland and the milk yield of primiparous cows.

Introduction

The knowledge of udder tissue structure in late-gestation heifers enables the yield of primiparous cows to be predicted. Current biochemical methods involve the determination of DNA, RNA, total protein and fat in parenchyma of the mammary gland either postmortem or through biopsy (Park et al., 1987; Capuco et al., 1995; Choi et al., 1997; Dobos et al., 2000; Silva et al., 2002). Also intermediate methods for determination of "productive value" of udder in heifers have been used. They are based on monitoring the growth rate of teat length in the front and hind quarters (Moran et al., 1991; Lammers et al., 1999; Lammers and Heinrichs, 2000).

Ruberte et al. (1994) used ultrasound measurement technique to measure the mammary gland in small ruminants. Caja et al. (1999) in sheep and Wójtowski et al. (2002) in goats, showed the usefulness of USG technique for measuring the milk cistern. However, there is a shortage of studies on the use of the ultrasound method for assessing tissue structure of the udder in heifers and for predicting on this basis their later productivity.

The aim of this study was to determine the suitability of USG technique for assessing the mammary gland structure in heifers prior to calving. The method involves the estimation

of secretory and adipose tissue content of the udder based on USG images, which may help to predict the milk yields of primiparous cows.

Material and methods

Ultrasound tests were made on 25 Black-and-White (62.5-92.1%HF), 25 Red-and-White (53.5-87.5% HF Red) and 25 Simmental heifers between 15 and 7 days prior to predicted time of calving. USG measurements were made with Aloka SSD-500 ultrasound device (Aloka Co., Ltd., Japan), equipped with a 35 MHz linear array transducer with a 120 mm field of view. Measurements were taken in a barn in stalls, within 2-3 hours of the morning feeding. Analysis was made on healthy animals that showed no clinical signs of mastitis or excessive nervous irritability during the tests. The lubricated transducer was placed across the front right quarter of the udder, ensuring that the edge of the emission area was at half-height of udder attachment.USG images were transmitted through CSS Video Fost Frame Grabler card into a computer and stored in the form of disk files (bitmap). Percentage of secretory and adipose tissue in the parenchyma was measured on previously saved USG images, using Multi Scan® ver. 8.08 software. In each USG image was delimited an area, which was a portion devoid, as far as possible, of artifacts (Fig. 1). Using the software, each recorded USG image was binarized according to a predetermined level of saturation and brightness level was determined on a grey scale in the luminance range of 0-255**.** The lower and upper brightness limits of the image were 128 and 255, respectively. Pixels with brightness values of 0 to 127 were assigned to the adipose tissue (hypoechogenic), and pixels with brightness values of 128 to 255 were assigned to the secretory tissue (hyperechogenic) of the udder quarter. In the predetermined image area, the fields of bright and grey image were determined and percentages of bright and grey areas in the total area were calculated.

Milk performance was evaluated based on maximum production (MP) obtained during the first 100 days of lactation and total yields of milk, fat, protein and lactose. Cows were milked twice daily. Milk outputs obtained from each cow were measured daily with TRU-TEST milk meters, and milk composition was determined at weekly intervals using Milko-Scan FT 120 (Foss Electric).

Animals were fed according to IZ-INRA allowances (2001)

Statistical calculations of the production indicators were made with one-way analysis of variance using the GLM procedure of SAS software (1989), while the correlation coefficients between secretory tissue (ST) percentage in mammary gland and subsequent yield milk (YM) were estimated with the CORR procedure.

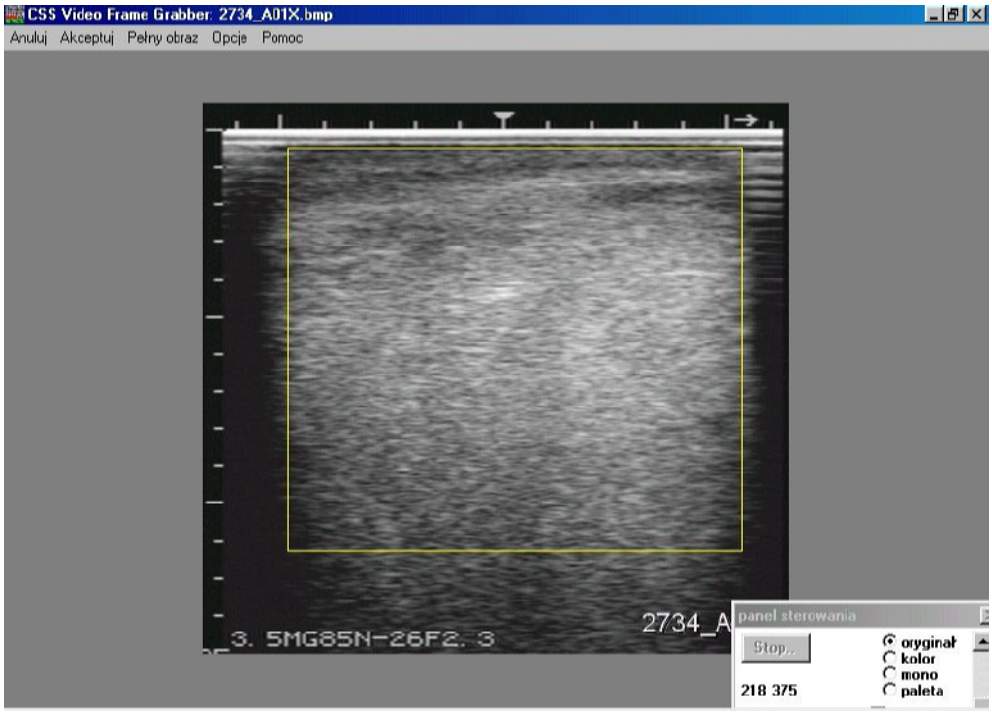

Fig. 1. Field of USG image without artifacts

Results

The highest milk yield was characteristic of Black-and-White heifers and the lowest of Simmentals (Table 1). Within each breed, animals with a higher milk yield were characterized by higher ST percentage in the udder quarter tested.

The correlation coefficients, estimated for each breed between ST percentage in the udder quarter tested and YPM during the first 100 days of lactation ranged from 0.802 to 0.855 (Table 2).

Discussion

The USG images obtained were not always of good quality, which was mainly due to the behaviour of animals. When a heifer was uneasy and moved during the tests, the measurement had to be repeated several times to obtain a clear picture suitable for further processing. The higher ST percentage in the right quarter of the mammary gland, found in higher-yielding compared to lower-yielding primiparous heifers, allows a conclusion that the applied method of assessing the mammary gland structure can be used for predicting the milk yield of primiparous heifers. This is attested to by the high correlation coefficient between percentage of ST in the tested quarter of the udder and YM of the heifers. However, the question arises if a heifer's productivity can be predicted from the USG measurement of the mammary gland structure of only one udder quarter. Possibly, it might be worthwhile to

determine the structure of all udder quarters and the relationship between ST content in each udder quarter and the milk yield of primiparous heifers.

Table 1. The udder structure and milk yield of primiparous cows

Item	Breeds					
	BW x HF		RD x HF Red		Simmental	
	Level of production					
	lower	higher	lower	higher	lower	higher
The udder structure before calving:						
- reading diagram (mm):	1110.3	1042.7	1110.2	1176.8	968.5	1106.0
- the secretory tissue content (%)	33.73	44.53	23.90	40.43	23.00	27.11
- the fatty tissue content (%)	66.27	55.47	76.10	59.57	77.00	72.89
Total milk yield, kg	2637.2	2878.4	2491.1	2720.4	1531.3	1707.9
Fat yield, kg	108.9	119.7	101.4	110.9	65.1	71.9
Protein yield, kg	84.4	92.7	80.5	87.3	51.7	56.4
Lactose yield, kg	128.9	139.4	121.5	131.4	74.3	83.8
PM [1], kg/day	29.0	30.41	28.5	30.2	18.3	19.1

[1] peak milk production according to INRA (1988)

Table 2. Relationship between the secretory tissue content in the udder (ST) and yield production milk (YPM) in 100 - day lactation

Breed	The secretory tissue content in the udder (%)	Regression equations (Y= a + b x)	Correlation coefficient R (Level of statistical significance P≤0.0001)
Black and White	35.89	YPM= 2070.5 + 17.13 ST	0.855
White and Red	31.99	YPM = 2090.7 + 15.38 ST	0.826
Simmental	24.65	YPM = 911.8 + 28.00 ST	0.802
Total	30.81	YPM = 1438.4 + 27.30 ST	0.667

Conclusions

Ultrasound images allow for assessment of the mammary gland structure. The use of USG technique enables noninvasive determination of the udder structure and, on this basis, the milk yield of primiparous heifers. The testing technique should be constantly improved.

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