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Brief Communication

Quantitative Estimation of Residual Milk in Bovine Udders – A Methodological Study

Residual milk in the dairy cow is the milk left in the udder after as complete an udder evacuation as is possible in practise by machine or hand milking. In the former case the residual milk quantity is to a large extent influenced by the milking machine and the way the machine is used. Maximum milk yield – over day, lactation period and lifetime – requires, among other things, that this quantity is kept at a low level. A new method for quantifying the residual milk is presented here. It concerns udders of machine-milked cows slaughtered after their final milking and is based on quantitative determinations in the udder tissues of lactose, the concentration of which in normal milk is more stabile than that of other major milk constituents. The method may be useful in testing machine milking systems/machine components and milking techniques for their ability to evacuate the udder.

Seven SRB (Swedish Red-and-White) cows, 5-10 years old, were involved in the investigation. Three of them were milked by competent milkers twice a day for one week using the same milking units and liners for the individual cows throughout the week, except for two consecutive milkings when quarter milkings were done with a special machine. After the last milking (morning) in their home barn, the cows were brought to the abattoir where they were carefully milked once again and then slaughtered. They were non-mastitic and had symmetric udder halves (Table 1, I-III). Two other cows were selected from among the cows brought to the abattoir for slaughter. They were carefully milked and then slaughtered. Both cows were mastitic. The udder halves were symmetric in one of them but asymmetric in the other one (Table 1, IV-V). The two additional cows were also selected at the abattoir. After careful milking, they were injected with 50 IU oxytocin (Partoxin vet., Ferrosan) intravenously, milked again after 5 min, and slaughtered. They were non-mastitic and had symmetric udder halves (Table 1, VI-VII).

All milked-out milk quantities were recorded. The udders were brought to the laboratory immediately after slaughter. They were divided into a right and a left half. Skin and teats were removed, as were also the median ligament and most of the loose connective and adipose tissues around the udder corpus. Each half was cut into pieces the size of a hen's egg, minced in an electric mincing-machine (Bosch kitchen machine), homogenized in an electric turmix (Bosch kitchen machine with rotating wings), and weighed. The effect of the mincing and homogenization was checked by microscopic examination of slides of formalin-fixed and paraffin-embedded material stained with hematoxylin-eosin and according to van Gieson. Representative samples were taken from both halves of the respective cows and processed in the following way for quantitative determination, primarily of lactose and secondarily of glucose and galactose.

Five g of each udder half homogenate was leached with water and defatted in the way

Table 1. Quantitative estimation of residual milk in bovine udders. One or two (after oxytocin treatment) abattoir milkings immediately before slaughter. Weight refers to udder halves after mincing and homogenization, lactose to analysis of homogenized samples. Residual milk is calculated as 4% lactose milk.

Cow	Daily yield kg	Abattoir yield g	Right and left halves					Udder health status
			Weight g	Lactose g/1000 g and total		Res. milk g/1000 g and total		
I	26	1000	6 480	12.7	82.3	2 060	4 170	Not
			6 440	13.1	84.4	2 110		mastitis
II	28	1000	7 520	17.3	130.1	3 250	6 400	"
			7 240	17.4	126.0	3 150		
III	21	1500	8 400	14.6	122.6	3 060	6 030	"
			8 300	14.3	118.7	2 970		
IV	16	1500	6 750	11.0	74.2	1 860	3 520	Fibrous
			6 900	9.6	66.2	1 660		mastitis all qua.
V	15	4000	10 150	20.2	205.0	5 130	7 180	Chr. pur.
			5 690	14.4	81.9	2 050		mastitis & atrophy LH
VI	-	3000	4 000	6.1	24.4	610	1 190	Not
		+3800[x)]	4 050	5.7	23.1	580	+3 800[x)]	mastitis
		6800					4 990	
VII	-	8000	5 250	7.1	37.3	930	1 920	"
		+2400[x)]	5 150	7.7	39.7	990	+2 400[x)]	
		10400					4 320	

[x)] = after oxytocin treatment.

prescribed for meat sausage (*Anon.* 1986). The samples were cleaned with a solid phase extraction system (Bond Elut C18, Analytichem International), filtered through a 0.45 µm membrane filter, and injected on a HPLC (high performance liquid chromatograph) consisting of a 5000 LC pump with autosampler 8055 (Varian), a refractive index detector Multiref 902 (Tecator) thermostated at 40°C, and an Aminex HPX-87P HPLC column (Biorad) maintained at 85°C. Evaluation of the chromatograms was done with the ABC 800 dator system (Luxor) and Chromatic software (Kebo Computor Application). Water was used as the mobile phase. Examinations of duplicate, or multiple, samples proved not to be needed.

Table 1 presents the udder health status of the cows, their daily yield before slaughter (when known), the milk quantities obtained in the abattoir from the five cows not treated with oxytocin (I-V) and from the two remaining cows (VI-VII) before and after the oxytocin treatment, and the weights of the udder halves within cow after mincing and homogenization (dissimilar in cow V). The weights tallied the udder conformation of the respective cows, and the quarter yields of the three quarter-milked cows as well. The table also presents the lactose content of the udder halves per 1000 g of homogenate and totally, and the residual milk quantity per udder half and per udder calculated as 4% lactose milk. In cows VI-VII the milk obtain-

ed at the pre-treatment milking is added (lactose percentage of the added milk not considered). The milk quantities produced in the udders between final milking and slaughter were no doubt negligible.

The glucose content of the udder homogenates amounted to appr. 2% of the lactose content, and the galactose content was still smaller. The microscopic examination of udder homogenate revealed no undestroyed alveolar structures, some adipose tissue, and relatively large amounts of connective tissue and undefinable masses of destroyed tissues. Therefore, the mincing and homogenization was considered satisfactory.

Lactose is a disaccharide composed of one molecule each of glucose and galactose (monosaccharides) and produced in the mammary alveolar cells. It is a normal milk constituent of most mammalian species, but is normally not present in the body outside the mammary glands. Its concentration in bovine milk is usually 4.5-5.0 %. The milk also contains traces of glucose but no galactose. The very small content of these monosaccharides in the udder homogenates indicates no substantial storage of them in the alveloar cells. Lactose does not seem to be stored in the cells either. Its production and secretion are closely interrelated to that of fat and protein (*Keenan et al.* 1974), which are known to be released into the alveolar lumina as soon as they have been elaborated (*Hollmann* 1974). These facts support the view that intracellular lactose constitutes such a small proportion of the total lactose content of the examined homogenates that it can be neglected in the present context. The lactose values of Table 1 are therefore considered to represent the lactose content of secreted milk and have as such been used for the calculations of the residual milk quantities.

The reasons for the choice of 4% lactose milk are the following. The fat percentage of the milk increases during the milking procedure and is often as high as, sometimes even higher than, 10% in samples taken after careful machine-stripping (*Lind* 1985). In residual milk it is assumed to be still higher. Lactose is contained in the water phase of the milk. The higher the fat percentage, the smaller - in relative terms - the volume of the water phase and the lower the lactose percentage in the combined water and fat phases. Four per cent of lactose in residual milk would therefore be a more appropriate figure than the 4.5-5.0% referred to above.

The mean residual milk quantity was 5230 g, exceeding the mean milk quantity obtained at the last (second last in the oxytocin-treated cows) milking by 2370 g. However, the cows were unaccustumed to the milking situation in the abattoir, and their individual variations were very great. Generalizations are not possible. The mastitic cows demonstrated no specific features in common.

The milkings after oxytocin treatment left considerable milk quantities in the udders. Oxytocin-induced milk is therefore not equivalent to residual milk, but rather part of this milk portion. Those who use the terms as synonyms should reconsider their definitions. The residual milk concept should be brought into accordance with the residual air concept which in physiological textbooks is applied to the air left in the lungs after maximal expiration.

The method presented here can be refined by performing the last milking and slaughter of studied cows in their home barn. Morning and afternoon milkings could be studied separately. The results could be related to the actual stage of lactation and the actual yield. Mastitic cows will probably exhibit a very great individual variation due to differences between the single animals with regard to the localization, extension, type and intensity of the inflammatory processes.

Axel Isaksson and Lars Arnarp
National Veterinary Institute, Uppsala, Sweden.

References

Anon.: Determination of Lactose/D-glucose. Cat. no. 986 119. Biochemical analysis brochure, Boehringer Mannheim GmbH, West-Germany 1986.

Hollmann K H: In Larson, B.L. & V.R. Smith: Lactation. Part I. Academic Press, New York & London 1974.

Keenan T W, Morré D J, Huang C M: Ibidem. Part II.

Lind O: Unpublished observations, 1985.

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