



The quantification of the economical losses caused by *Staphylococcus aureus* in a large-scale Holstein-Friesian dairy cattle farm

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ABSTRACT

According to surveys carried out in Hungary and in countries with advanced cattle-keeping, in the dairy cattle sector mastitis causes the largest economic losses on herd level. In the last decades such udder bacteria have been spreading which are resistant to a lot of antibiotics, and nowadays in most of dairy cattle farms the Staphylococcus aureus is responsible for most of mastitis cases. The direct consequence of Staphylococcus aureus infection is that both the quality and the quantity of milk produced by the infected animals considerably deteriorates and as a result it is impossible to produce quality milk in long term in dairy farms with infected cows. In the article a model calculation was shown to quantify the losses resulting from mastitis caused by Staphylococcus aureus. The surveys were performed at an average, Hungarian large-scale Holstein-Friesian dairy farm in 2001, and the production factors of Staphylococcus aureus positive cows were compared with those of healthy ones (control group). For calculations the natural and economical data of the dairy farm were used. According to the result of the calculations Staphylococcus aureus infected cows annually produce 583 kg less milk on average than the healthy cows and the average SCC of their milk is over twice as high (exceeds the 400 SCC/ml) as in the case of the healthy ones. The annual loss caused by the 53 Staphylococcus aureus-positive cows in the examined farm is more than 5 million HUF! The yearly loss per infected cow comes up to almost 100 000 HUF. For 59% of this loss the reduced milk income is responsible, in 39% premature disposal can be blamed, while the easily demonstrated cost of medical treatment amounts to only 2% of the losses.

(Keywords: *Staphylococcus aureus*, dairy cattle, mastitis, economical losses, model calculation)

ÖSSZEFOGLALÁS

A *Staphylococcus aureus* tőgygyulladás által okozott gazdasági veszteségek számszerűsítése egy nagyüzemi holstein-fríz tehenészetben

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A fejlett szarvasmarhatartással rendelkező országokban és a hazánkban elvégzett felmérések alapján a tejelő szarvasmarha ágazatban a betegségek közül állomány szinten a tőgy-

gyulladások okozzák a legnagyobb gazdasági veszteséget. A tőgygyulladás kóroktanát elemezve elmondható, hogy az elmúlt évtizedekben elterjedtek a számos antibiotikumnak ellenálló baktériumfajok, és ezek közül napjainkban a *Staph. aureus* felelős a tőgygyulladások igen nagy hányadéért a tejtermelő gazdaságok többségében. A *Staph. aureus* fertőzöttség közvetlen következménye, hogy a fertőzött állatok tejtermelése csökken, és a termelt tej minősége is oly nagymértékben romlik, hogy a fertőzött teheneket fejő tehenészetben hosszabb távon lehetetlen minőségi tejet termelni. A cikk modellszámítást mutat be a *Staph. aureus* miatti tőgygyulladások által okozott éves állományszintű veszteségek számszerűsítésére. A vizsgálatokat egy átlagos hazai, nagyüzemi holstein-fríz tehenészetben végeztük 2001-ben és a *Staph. aureus*-pozitív tehenek termelési mutatóinak átlagadatait hasonlítottuk össze az egészséges tehenek (kontroll csoport) átlagadataival. A számításokhoz a vizsgált telepre jellemző természetes és ökonómiai adatokat vettük figyelembe. A számításaink eredményei szerint a *Staph. aureus* fertőzött tehenek átlagosan éves szinten 583 kg-mal kevesebb tejet termelnek, és az általuk termelt tej szomatikus sejtszáma is több mint kétszerese az egészséges állatokénak, meghaladja a 400 ezer SCC/ml-t. Az 53 *Staph. aureus*-pozitív tőgygyulladásos tehen által okozott éves veszteség a vizsgált telepen több mint 5 millió Ft! Az éves veszteség fertőzött tehenenként közel 100.000 Ft! A tejárbevétel-csökkenés felelős ezen veszteségek 59%-ért, 39%-ért az idő előtti selejtezés okolható, míg a jól kimutatható gyógykezelési költség a veszteségeknek csupán 2%-át teszi ki. (Kulcsszavak: *Staphylococcus aureus*, tejelő szarvasmarha, tőgygyulladás, gazdasági veszteségek, modellszámítás)

INTRODUCTION

In the present circumstances of cattle-keeping one of the most frequent forms of mastitis accompanied by the greatest economic losses is caused by *Staphylococcus aureus*, all over the world. Since machine milking has become predominant universally 30-40% of mastitis cases accompanied by acute and subacute symptoms and 40-60% of subclinical mastitis cases are brought on by this pathogen. Its frequency and consequently the economic losses it causes may reach catastrophic dimensions in certain dairy cattle herds. The extent of the economic losses may only be compared to those caused by classic epidemics (Simon *et al.*, 2000).

The incidence of *Staphylococcus aureus* abroad and inland

Staphylococcus aureus has always been and at present is one of the most important pathogens causing mastitis in milking cows (Assche, 2000). Results of surveys carried out in the Netherlands show that clinical mastitis occurs on average 28%, subclinical mastitis in 11% and 11% of clinical mastitis cases and 40% of subclinical mastitis cases are caused by *Staph. aureus* (Dijkhuizen & Morris, 1997). In Switzerland 54% of mastitis is caused by this pathogen (Kasche, 1995). In Germany this bacterium was detectable in 13% of the clinical mastitis cases (Kasche, 1995). In Norway it causes 27% of the clinical mastitis and 48% of the subclinical mastitis (Kasche, 1995). During surveys carried out in Australia 9% of the cattle was diagnosed to have clinical mastitis, 38.5% of which was caused by *Staph. aureus* (Kasche, 1995). According to surveys in the USA 25% of the clinical mastitis cases were caused by *Staph. aureus* (Kasche, 1995). In Argentina 54% of animals with subclinical mastitis were *Staph. aureus* positive (Kasche, 1995). Data demonstrate that abroad a significant percentage of mastitis cases – in several countries more than half of subclinical mastitis – were caused by *Staph. aureus*.

From 1988 to 1999 77 350 milk samples from udder quarters went through bacteriological tests in Hungary. On the basis of summarized bacteriological evidences the frequency of the bacterium did not change much between 1988 and 1993, the values were about 65-70%. In 1994 the frequency of *Staph. aureus* was 74.5% (that was the peak), but by 1999 this value had decreased to 43% owing to the results of the widely started elimination program (Simon et al., 2000).

The Gödöllő Livestock Performance Testing Ltd. tested 1 072 milk samples from udder quarters with mastitis in 1997 and cultured some kind of bacteria from 686 samples. According to the test results 51% of the pathogens was *Staph. aureus* and 10.3% was coagulate negative Staphylococcus (Antal et al., 1998).

In the 1st half of 2001 among the 10 170 milk samples tested by a Hungarian private laboratory 2 275 (22.4%) were positive bacteriologically, in 800 (35.2%) of which *Staph. aureus* was detected (Markus, 2001). In a dairy farm milking 400 cows on average 16.8% of the sterile milk samples proved to be *Staph. aureus* infected (Simon et al., 2000). In the Ödön-major dairy of Bicskei Mg. Rt. keeping 800 Holstein-Friesian milking cows, according to the bacteriological tests carried out in 2001 16% of the mastitis cases were caused by *Staph. aureus* (Soltész, 2001). It is observable from the published data that *Staph. aureus* is one of the most widespread pathogens causing mastitis not only in foreign countries but also in our country!

The influence of *Staphylococcus aureus* infection on production indexes and the extent of losses

Due to mastitis (clinical and subclinical) the quantity of produced milk decreases and the quality also becomes significantly lower. If the Somatic Cell Count (hereinafter: SCC) of the bulk milk in a dairy cattle herd is 400-500 thousand/ml or more, in most of the cases there is subclinical mastitis caused by *Staph. aureus* (in minimum 6-8% of the herd) in the background (Simon et al., 2000). The influence of *Staph. aureus* infection on SCC was examined in a domestic herd under *Staph. aureus* elimination, where the SCC of the bulk milk of *Staph. aureus* negative groups was 280 000, while the SCC of the bulk milk of *Staph. aureus* positive group was 480 000 (Markus, 2001).

Model calculations for the estimation of economic losses caused by *Staph. aureus* mastitis have already been made in the Netherlands and in our country. Based on a survey carried out in numerous dairy cattle farms, in 1997 the total incidence of cows with clinical mastitis in a Dutch herd was 28% and 3% of the cows were infected by *Staph. aureus* on average. This means, considering 1.4 infected udder quarters per mastitis, 4.2 (3×1.4) clinically infected quarters per 100 cows. In mastitis caused by *Staph. aureus* milk production decreased by 26% per quarter annually on average, the culling rate was 14%, and the quantity of milk fat was reduced by 4% as well. According to the surveys carried out the average incidence of subclinical mastitis in dairy herds in The Netherlands amounted to 11.1%, and 40% of this was caused by *Staph. aureus*. The losses were restricted to the decrease in milk production (4.6% per lactation) and the reduction of the quantity of fat (1.9% per lactation) (Dijkhuizen & Morris, 1997). According to Dijkhuizen & Morris the clinical mastitis of *Staph. aureus* caused a 337 US\$ average annual loss per infected cow in 1997, while its subclinical mastitis caused a 41 US\$ loss.

In Hungary calculations were made to estimate the losses caused by mastitis on the basis of the rate of change of production indexes in the abovementioned survey in The Netherlands, considering basic data typical of an average Hungarian dairy cattle farm. The model calculation was done for a Hungarian dairy cattle herd keeping 1000 milking

cows, where the average annual milk production was 8 000 kg/cow/year. In the calculation of the losses the agro-economic circumstances of the year 2000 were taken as a basis. The results of these calculations showed that the clinical mastitis caused by *Staph. aureus* resulted in an annual loss of 57 627 HUF per infected cow, while the subclinical mastitis – 5 632 HUF (Ózsvári, 2000).

Aim of the study was to quantify the economical losses caused by *Staph. aureus* mastitis in a large-scale Holstein-Friesian dairy cattle farm.

MATERIALS AND METHODS

Our surveys were carried out in an average large-scale dairy cattle farm in Central-Hungary in 2001, where at the time of finishing the surveys (December 2001) 928 Holstein-Friesian cows were kept, 735 of which were milking cows. There are 6 loose housing system stable buildings for 120 cows each, to which paddocks were connected as well. There was no hospital-barn, the diseased cows were placed at the end of the calving stable. The calving stable also had loose housing system and a layer of straw was provided as bedding. The production groups were milked separately through Boumatic parallel milking parlours with 2×20 stands. The cows with clinical and subclinical mastitis were separated into the last group during milking. The average annual milk production of the cows was 7 570 kg, with a 3.6% milk fat and a 3.3% milk protein on average. The average length of the lactation was 305 days, and of calving interval was 420 days. The dairy cattle herd was free from brucellosis, leptospirosis, tuberculosis and leucosis. Milk sampling was done during test milking by an automatic measuring device built into the milking system. SCC is determined in a laboratory with a Fossomatic device. The bacteriological testing of the milk samples was performed by the Gödöllő Livestock Performance Testing Ltd.

The purpose of our study was to quantify the economic losses due to mastitis caused by *Staphylococcus aureus* in the given large-scale dairy cattle herd which was executed with model calculation. The method of partial budgeting was used in the calculations; the basic logic of which is that changing the value of production indexes it is possible to calculate how much extra income would be derived from the absence of the disease in the herd. The results of the model calculations used to estimate and account the extent of the losses may greatly differ, depending on the used method, on the authenticity of the data and on what include in losses. Therefore the extent of the losses originating from different calculations could be different.

In this model the losses caused by mastitis can be divided into three categories: reduced milk receipts, costs of treatment and costs of premature disposal. The reduced milk receipts are caused by the decreased milk production, the discarded milk (the separation of the milk from cows under medical treatment) and the lowered milk quality. In the calculations it must be considered that each kilogram of milk not produced means 0.5 kg of milking concentrate remaining (Ózsvári, 2000). In Hungary the milk sample qualification system is based on bulk milk sampling. The economic effect of the decreased milk quality was not calculated in this study, because the decreased bulk milk quality occurring in the examined period (during 2001) is proved to have been due to residuum and not because of SCC increasing to over 400 000/ml. The costs of treatment include the veterinary fees, the drug expenses and the farmer's labour. However, the veterinary with fixed salary was employed in the examined dairy cattle herd, hence the veterinary fee did not need to be calculated in the quantification done with partial budgeting. The „farmer's labour” implied the employees' labour in this case, so the

„farmer's” labour did not need to be calculated either, as this activity is part of the jobs of the employees with fixed salaries. During the calculation of losses caused by premature disposal the slaughter value of the culled cow and the costs of the replacement were considered.

Data were collected between 1st January and 31st December 2001. The used data were from the computer log of the farm. Those cows were considered as healthy (control group) in the dairy cattle herd which never had any kind of mastitis diagnosed. The average milk quantity, milk fat%, milk protein% and SCC of lactations closed in 2001 of cows having mastitis caused by *Staph. aureus* were compared to the average parameters of the control group in lactations closed in 2001. The cows having mastitis and the healthy ones were paternal half-breds. After determining the difference between the averages of milk production of cows having *Staph. aureus* caused mastitis and healthy cows the milk loss per lactation was calculated in the knowledge of the milk price. Having known the average length of calving interval the annual losses on animal and on herd level were calculated, so data became comparable for other dairy cattle farms having similar production characteristics.

When intramammary antibiotic treatment is applied, milk has to be separated which is also a source of loss. Knowing the intramammary drugs and their methods of application the total number of days of the withdrawal period in 2001 was calculated for clinical as well as subclinical mastitis, and after the average daily milk production of cows with mastitis (clinical and subclinical) was defined the loss due to discarded milk could be quantified. The costs of drugs were evaluated by taking the total sum of prices of intramammary drugs used in 2001 for treating all the diseased quarters of *Staph. aureus* positive cows. The costs of premature disposal were calculated from the differences of replacement costs and the slaughter values of the culled cows.

In 2001 the price of 1 liter of extra quality milk was 75 HUF, and the price of 1 kg of milking concentrate was 40 HUF in the case of the given dairy cattle farm. During the survey period 17 *Staph. aureus* positive cows were culled, the slaughter price of 4 was 195 HUF/kg (II. class), the price of 6 was 180 HUF/kg (III. class) and the price of 7 was 125 HUF/kg (IV. class). The average weight of a culled cow was 500 kg and the replacement cost in the herd was 200 000 HUF/heifer with calf, which were selected from their own progeny.

RESULTS AND DISCUSSION

The number of quarter milk samples tested by Livestock Performance Testing Ltd. in 2001 was 286. Samples were taken from only one quarter of each cow. Among the tested samples 53 (18.53%) were *Staph. aureus* positive, 4 (1.4%) were CNS positive, 20 (6.99%) *Staph. sp.* positive and 1 (0.35%) was *Staph. intermedius* positive beside several other bacteria, which shows that *Staph. aureus* caused the mastitis in a high percentage of the cases. The percentage of *Staph. aureus* infected cows was 7.2% in 2001 compared to all the milking cows (735 animals). Of the 53 *Staph. aureus* positive quarters – on the basis of Mastitest examination – 16 (30.19%) had clinical mastitis and 37 (69.81%) had subclinical mastitis, that is *Staph. aureus* mainly occurred in subclinical form in the herd. 2.2% of all the milking cows had clinical and 5% had subclinical *Staph. aureus* mastitis in 2001.

Table 1 shows the average test milking values of lactations closed in 2001 of cows with *Staph. aureus* positive quarter (53 cows) and the control group (194 cows).

Table 1

Average test milking values of healthy and *Staph. aureus* positive cows

Groups (1)	Number of cows (n) (2)	Average milk production (kg/day) (3)	Average SCC (1000/ml) (4)	Average milk fat% (5)	Average milk protein% (6)
Control (7)	194	24.76	193	3.70	3.29
<i>Staph. aureus</i> positive (8)	53	22.56	435	3.78	3.29
Of which:					
Clinical mastitis (9)	16	22.42	428	3.76	3.25
Subclinical mastitis (10)	37	22.64	439	3.79	3.31

1. táblázat: Az egészséges és a *Staph. aureus* pozitív tehenek átlagos befejési értékei

Csoportok(1), Tehénlétszám (n)(2), Átlagos tejtermelés (kg/nap)(3), Átlagos SCC (ezer/ml)(4), Átlagos tejszír%(5), Átlagos tejfehérje%(6), Kontroll(7), *Staph. aureus* pozitív(8), Ebből: klinikai tőgygyulladás(9), Szubklinikai tőgygyulladás(10)

The data in Table 1 show that *Staph. aureus* infected cows produced less milk than the healthy ones. The average daily production of the diseased cows was 2.2 kg less than in the control group. This means 671 kg/cow on lactation level and annually 583.13 kg/cow decrease in milk production on average. The average daily milk production of *Staph. aureus* positive cows with clinical mastitis decreased at a greater extent (by 2.34 kg) compared to the production of the control group than the production of the cows with subclinical mastitis, where the decrease was of 2.12 kg.

Comparing the SCC of the two groups a great increase may be detected in the case of cows with mastitis. It is observable that the average SCC of cows with clinical and subclinical mastitis is approximately the same, over 400 000/ml, that is the quality deterioration of the produced milk is significant. At the same time it is interesting to see that the average daily milk fat% produced by infected cows is nearly 0.1% higher than the values measured in the control group – this is conspicuous especially in the case of the subclinical form – and the average milk protein% basically did not change.

The most considerable element of reduced milk receipts due to *Staph. aureus* is the loss generating from the decrease in milk production, which is moderated by the value of the milking concentrate remaining because of the decreased milk production (0.5 kg concentrate/1 kg not produced milk). Therefore the loss due to decreased milk production was 1 691 205 HUF in the case of *Staph. aureus* infected cows. The total number of days of the withdrawal period due to the treatment of *Staph. aureus* positive cows in the dairy herd was 814.5 in 2001. The cost of discarded milk was 1 377 453 HUF calculated with the average daily milk production of cows with clinical and subclinical mastitis.

In 2001 17 of the 53 *Staph. aureus* positive cows – 6 with clinical and 11 with subclinical mastitis – were culled, which means that 32.1% of the infected cows (37.5% of the cows with clinical and 29.7% of the cows with subclinical *Staph. aureus* mastitis) were prematurely disposed. The cost of replacement was 3 400 000 HUF, while the slaughter value amounted to 1 367 480 HUF, thus the cost of premature disposal was 2 032 520 HUF.

Table 2**Calculated annual losses on herd level caused by *Staphylococcus aureus* mastitis (HUF)**

	Clinical (1)	Subclinical (2)	Total (3)
Loss due to reduced milk receipts (4)	546 795	1 144 409	1 691 205
Loss from discarded milk (5)	550 588	826 866	1 377 453
Cost of treatment (6)	37 668	59 910	97 578
Cost of premature disposal (7)	717 290	1 315 031	2 032 320
Total (8)	1 852 340	3 346 216	5 198 556
Loss per Unit (HUF/infected cow) (9)	115 771	90 438	*98 086

* Weighted mean (*Súlyozott átlag*)

2. táblázat: A *Staph. aureus* tőgygyulladás által okozott éves állományszintű veszteségek (Ft)

Klinikai(1), Szubklinikai(2), Összesen(3), Tejtermelés-kiesés miatti veszteség(4), Elkülönített tejből származó veszteség(5), Gyógyszerköltség(6), Idő előtti selejtezés költsége(7), Összesen(8), Fajlagos veszteség (Ft/fertőzött tehén)(9)

Table 2 shows that the annual losses caused by *Staph. aureus* mastitis in the examined dairy cattle herd exceeded 5 million HUF. Clinical mastitis was responsible for 36% – nearly 1.9 million HUF – and subclinical mastitis was responsible for 64% – over 3.3 million HUF. So, the subclinical mastitis resulted in much more economic losses on herd level, the cause of which was the higher rate of incidence on herd level. The annual loss per infected cow was approximately 100 000 HUF! Clinical *Staph. aureus* mastitis resulted in a 25 thousand HUF higher loss per cow than the subclinical form, exceeding 115 thousand HUF. 59% of all the losses caused by *Staph. aureus* mastitis was from the reduced milk receipts, 39% was from the premature disposal, while the well-detectable costs of treatment made up a mere 2% of the losses.

CONCLUSIONS

Decreasing production losses may be one of the key factors of increasing profitability in stock-keeping farms. Since certain production losses are of small volume in themselves and thus avoid our attention, if they prevail for a longer time (e.g.: lower milk production), their significance becomes higher. Often, only a part of losses is directly visible – e.g.: deaths – another part is present in a hidden manner (e.g.: the reduced income due to decreased yields). The competent milk production requires the minimum losses owing to diseases on herd level. Our calculations modeling economic effect of mastitis caused by *Staph. aureus* also attract attention to the importance of handling the problem.

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