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MASTITIS OF DAIRY COWS AND FINANCIAL LOSSES: AN ECONOMIC META-ANALYSIS AND MODEL CALCULATION

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Abstract

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Economic losses caused by mastitis represent lower revenues and higher costs on milk production as compared with healthy cows. The aim of the study was to estimate possible value and variability of these losses by economic meta-analysis and consequent model calculation. Based on literature data and own calculations the economic loss per one case of mastitis occurrence was estimated at 9000 CzC [1 € = 25 CzC (Czech Crown)] for the conditions of the Czech Republic (CR). The lower revenues from the sale of milk (53%), higher culling of cows (herd recovery, 20%), higher costs for drugs and cow cure (14%), labour for treatment of ill cows (7%) and penalties of farmer milk price (6%) participate in these losses. The losses caused by mastitis can vary between 4000 and 18 000 CzC as a result of various factors (occurrence and intensity of disease, dairy cow milk yield, cow rearing costs, milk prices, etc.). In case of 35% sickened cows (130 thousands) from the current state of 373 thousands of dairy cows in the CR the total economic loss caused by mastitis can reach 1 170 000 000 CzC per year. The loss of 9000 CzC per cow with mastitis and 3140 CzC per dairy cow in herd is equal to revenue from sales for 950 and 330 litres of milk at the current farmer milk price 9.5 CzC per litre. Increasing the proportion of cows with mastitis by 1% in the CR would increase the economic loss by other 38 500 000 CzC. Regarding general occurrence of mammary gland inflammations of the cows and in order to reduce the high economic losses the high effective prevention and therapy of these production diseases have to be a regular part of the herd management.

Key words: cow, mastitis, milk losses, cow culling, drugs and cure costs, extra money, farmer milk price, benefit, lower milk quality penalty, economic losses

Abbreviations: AU$ – Australian dollar; CHF – Swiss franc; CA$ – Canadian dollar; CR – Czech Republic; CzC – Czech Crown; € – Euro; EU – European Union; F – fat; MFPD = milk freezing point depression; NZ$ – New Zealand dollar; P – protein; RIS – residues of inhibitory substances; SCC – somatic cell count; TCM – total count of microorganisms; US$ – US dollar

Introduction

Mastitis is the most common and economically demanding production diseases in dairy cows (Kron, 2002; Asseldonk van et al., 2010; Schroeder, 2012; Winter and Fehlings, 2013; Kvapilík, 2014). Lameness occurrence in cows is also very important from production point of view (Mitev et al., 2011; Varlyakov et al., 2012). In order to improve the economic results of milk production and maintenance of high quality dairy products the reduction of mastitis incidence is not under increased attention only in the Czech Republic (CR). It is mainly the effective prevention, early identification of problem cows and reliable methods and programs to reduce the number and proportion of mastitis in dairy cows to the economically acceptable level.

The goal of this paper: the study is focused on estimation of amount and ways how to reduce the economic losses caused by mastitis. The assesment of source proportions of

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mastitis losses is also one of goals. It can contribute to the stabilization of this important livestock sector in the CR and to higher competitiveness of Czech milk producers within the European Union (EU).

Materials and Methods

Calculation (estimation) of the economic losses caused by inflammation of the cow udder (following the previous contribution about mastitis production losses - Kvapilík, 2014) is based on the foreign and domestic publications. This is a model calculation which takes into account current production and economic conditions of milk production (as milk yield, milk composition and prices etc.) beside the data from literature sources. Several indicators of relationship between milk quality indicators and farmer prices are taken from international results which were published by the Bavarian Milchprüfring Bayern e. V. (2014). Currently published data about milk quality and payment were collected, classified according to united pattern, evaluated by economic meta-analysis, commented and used for consequent economic model calculation. Data were processed by standard mathematical and statistical procedures. The economic values were converted from the EU currency to CR currency at the exchange rate € 1 = 25 Czech Crowns (CzC). At the convertion of other currencies the exchange rates which were published by the Czech National Bank (2014) are taken into account.

Results and Discussion

Mastitis and main production losses

Each dairy cow disease has to result in a number of production losses. The main economically significant losses due to mastitis include lower sales of milk, higher cow culling (herd recovery), higher veterinary performance and labour consumption which is associated with mastitis, worse indicators of fertility and lower milk fat and protein percentage (Kvapilík, 2014). Detected (estimated) production losses caused by mastitis are characterized by considerable variability in practice as well as the most indicators of biological nature. The reasons for this variability are beside dairy cow individuality also for instance breed, milk yield, natural and economic conditions, technological lines (such as kind of housing, milking, feeding, etc.), feeding rations, herd management and so on. The estimation of production losses per (case) mastitis occurrence (case) is shown in Table 1. Somatic cell count (SCC in $10^3.ml^{-1}$) in milk is one of reliable and relatively easy detectable indicators which can be used for assessment of health status of cow mammary gland. Therefore, there are estimated the production losses by the development of this indicator in Table 2. A significant mastitis impact on evaluated indicators and their variability and production losses in dairy production is apparent from both Tables (1 and 2).

Mastitis and economic losses

Economic losses caused by inflammation of the mammary gland of cows represent production losses and higher costs associated with the disease which are expressed in money as compared to healthy dairy cows. These include:

- lower revenues from lower sales of milk per cow;
- higher costs on herd recovery (losses by cow culling);
- costs on milk sample analysis, medicine and veterinary performance;
- costs associated with the labour of stable staff and relevant care about mastitis cows (higher operating costs);

Table 1
Estimation of production losses (per clinical mastitis case)

Loss type – indicator	Unit	Production loss	
		average	range
Lower milk yield	milk per cow, kg	350	200 – 500
Milk exclusion of supply (withdrawal period)		200	50 – 300
Lower milk sale in total		550	250 – 800
Longer service period[1)]	day	15	0 – 25
Higher insemination index	%	0.3	0 – 0.5
Worse conception rate		5	2 – 15
Higher culling (herd recovery) per 100 cows	cow	5	0 – 10
Lower milk fat content	%	0.3	0.03 – 0.5
Lower milk protein content		0.03	0 – 0.27
Higher labour consumption per cow with mastitis	hour/cow	2.0	1.0 – 4.0

Kvapilík, 2014; 1) also longer between-calving interval

Table 2
Estimation of production losses according to somatic cell count (SCC)

Loss type – indicator		SCC (10^3.ml^{-1})	Unit	Production loss	
				average	range
Lower milk yield (SCC in bulk milk)		200 – 300	milk per case, %	2	1 – 4
		301 – 400		4	3 – 6
		401 – 600		6	5 – 8
		600 – 1 000		9	6 – 18
Lower milk yield (SCC in individual cow milk)		100 – 300	milk per case, kg	150	0 – 300
		301 – 500		350	200 – 450
		501 – 700		450	300 – 600
		701 – 900		600	400 – 750
		over 900		800	500 – 1 000
Lower fat content	bulk milk	per 10.10^3 of SCC[1)]	%	0.025	0.005 – 0.5
Lower protein cont.				0.015	0.0 – 0.03
higher TCS[2)]			10^3.ml^{-1}	0.75	0.25 – 1.8

Kvapilík, 2014. 1) in SCC range from 100 to 300 10^3.ml^{-1}; 2) TCM = total count of microorganisms.

- worse indicators of fertility (longer service period and between-calving interval, less calves per year etc.);
- lower farmer milk (purchase) price due to lower milk fat content and lower protein content in milk;
- lower purchase price of milk due to the higher SCC and total count of microorganisms (TCM) in milk;
- other (higher costs for milk sample analysis, artificial insemination and possible higher incidence of other diseases, etc.).

Since the mastitis diseases occur in most herds of dairy cows the estimated economic losses caused by this disease are high. For example Wolter and Bonsels (2013) estimated annual losses due to mastitis in Germany at € 1.4 billion (about 35 billion CzC) which corresponds to the theoretical loss (increased costs and reduced profits) of 4.7 cents (1.18 CzC) per kg of milk. Each subclinical mastitis costs at least 250 € (6250 CzC), severe clinical mastitis costs up to about 500 € (12 500 CzC) per cow and lactation. Rüsch (2000) mentioned loss of 1545 millions € (around 6110 millions CzC) for enterprises with the milk production in Switzerland: every 5th cow is sick with acute mastitis, each 4th cow has chronic inflammation at least in one udder quarter and one of seven dairy cows is excluded from herd on the basis of an incurable mastitis. Diseases of the mammary gland are considered as the main source of losses also in Australia. Brightling et al. (1998) estimated annual amount of mastitis losses on 150 millions AU$ (approximately 2925 millions CzC).

Hogeveen et al. (2011) reported about published estimates of average losses caused by mastitis which are most often ranging between 61 and 97 € (1525 and 2425 CzC) for each (healthy and „mastitis“) cow. There was also significant variability of this indicator among dairy farms. The losses due to clinical and subclinical mastitis reach usually from 17 to 198 € (425 – 5950 CzC) per cow and year in the Netherlands. Jones and Bailey (2009) estimated annual losses due to mastitis in the USA at 1.7 to 2.0 billions US$ (about 36 to 42 billions CzC) which corresponds to 11% of annual milk production. The main losses are caused by a reduction in milk yield (loss of about US$ 102 and 2140 CzC), by milk excluding from the sale (US$ 24, 505 CZK) and by more intense cow herd recovery (US$ 33, 685 CzC) per cow and year.

Estimates of the economic impacts of mastitis in dairy cows published between 1991 and 2009 included Nielsen (2009). The loss caused by clinical mastitis was estimated by ten authors and this varies, with an average of € 290 (7250 CzC), between 71 € (1775 CzC) in CR (Wolfová et al., 2006) and 519 € (12975 CzC) in Great Britan (Kossaibati and Esslemont, 1997) per case of occurrence. The estimation of the impacts of subclinical mastitis disease (four cases) ranges between 60 and 130 € (1500 and 3250 CzC) and reaches 105 € (2625 CzC) on average per case of occurrence. The mentioned results are influenced also by methodological approaches to loss estimation among others. There are most frequently calculated higher herd recovery (in 93% of cases) and milk yield decrease, milk exclusion from sale in the framework of withdraval period (milk excluding from dairy factory delivery because of use of antibiotic drugs in cows) and consumption of drugs (in 86% of cases). The contagiousness and prevention are taken into account only in 14 and 7% of the twelve „types“ of mentioned losses.

Most of authors who are interested in economic losses cused by mastitis in dairy production agree in main types and causes of losses. There is apparently less agreement about recognized or estimated amount of these losses. Reporting variability includes differences in production losses (Table 1 and 2) and in methodological approaches to estimations (calculations) of losses and in fluctuations of economic indicators (prices of milk, labour costs, veterinary performance and other health interventions) among enterprises, regions and states. This fact is confirmed also by the data in Table 3. At the variation between approximately 4000 and 15 000 CzC the economic loss reaches approximately 8460 CzC per one case of mastitis and 1700, 3400 and 5100 CzC per cow of herd if 20, 40 and 60% of cows suffer from mastitis disease.

Losses from lower sales of milk

Since the main market product of dairy cow rearing is raw milk the reduction of the sale volume is the largest item of economic losses caused by inflammation of the mammary gland of cows. On average (Table 3) the total loss is created by approximately 40% (3365 CzC) of decrease in milk production per cow (milk yield) as a result of mastitis disease and by 18% (1545 CzC) of exclusion from milk sale as a result of the withdrawal period after treatment with antibiotics and other veterinary drugs. Due to the fact that detection of residues of inhibitory substances (RIS) in the delivered milk results in significant economic sanctions the laid down withdrawal periods of drugs are strictly adhered in the majority of cases. The annual fluctuations in the purchase prices of milk, method of treatment of cows and types of applied drugs,

Table 3
Economic losses by clinical mastitis (CzC[1])/cow/case)

Source	Lower milk yield	Withdrawal period[2]	Milk in total	Herd recovery	Treatment, drugs	Other items	Loss in total
Wolter and Bonsels, 2013[3]	4 375	700	5 075	x	x	1 175[4]	6 250
	8 750	1 375	10 125	x	x	2 375[4]	12 500
Lührmann, 2013[5]	3 075	2 150	5 225	3 125	2 375	850	11 550
	2 150	1 575	3 725	3 125	2 375	850	10 050
	1 225	1 100	2 325	3 125	2 375	850	8 675
	2 700	1 925	4 625	3 125	2 375	850	10 975
Egger-Danner, 2008[6]	x	x	9 750	1 825	1 500	x	15 275
Winter, 2009	3 486	2 415	5 901	3 759	2 940	798[8]	13 398
Krömker, 2007	6 850	525	7 375	4 525	900	200	12 925
Malkow-Nerge et al., 2014	3 275	2 325	5 600	3 125	2 375	700	11 800
Walkenhorst, 2000	2 585	1 880	4 465	2 350	1 410	x	8 225
Anonym, 2008	2 275	2 450	4 725	x	2 500	x	7 225
Harms, 2013	1 875	2 150	4 025	1 225	1 175	300	6 725
Heber, 2013	1 600	2 250	3 850	x	2 375	x	6 225
Tschischkale and Peters, 2006	1 750	1 950	3 700	x	2 375	x	6 075
Reiterer and Prünster, 2007[7]	3 725	425	4 150	550	275	500	5 400
Kvapilík and Růžička, 2009	3 970	680	4 650	365	210	x	5 225
Dyson, 2003	1 482	1 307	2 789	683	878	117	4 466
Schroeder, 2012	2 940	420	3 360	336	294	210	4 200
Anonym, 1996	2 541	219	2 760	876	212	24	3 872
Ø CzC	3 365	1 545	4 910	1 790	1 345	415	8 460
(estim.) %	40	18	58	21	16	5	100

1) 1 € = 25 CzC (Czech Crown), 1 AU$ = 19.5 CzC, 1 US$ = 21 CzC, 1 CHF = 23.5 CzC (used currency exchange ratios are valid for September 2014); 2) milk excluded from sale because of drug withdrawal period; 3) light and heavy course of mastitis; 4) it includes herd recovery, treatment and drugs and higher labour consumption (19% loss in total); 5) first, second and third period of lactation and total lactation (incidence 70, 20, 10 and 100% of mastitis); 6) heavy course of mastitis; 7) per each cow of herd; 8) longer service period (1,825 CzC) and higher breeding activities (375 CzC)

length and course of the disease and the methodology of loss survey etc. are among the reasons for the high variability of these two items (about 1500 – 8750 CzC and from 220 to 2450 CzC). For instance, at a lower selling by 500 litres of milk due to mastitis and the purchase price of one litre in the CR in 2009 (CzC 6.14) and 2013 (CzC 8.51), the difference in revenues for sold milk represents 1185 CzC. The differences in methodological approaches to estimation of these losses may consist of different taking into account (or disregard) the lower feed costs at a lower milk yield, decrease in milk yield in lactation after mastitis cure, the disposal costs of milk with positive RIS etc. for example.

The higher costs on herd recovery (loss from cow culling)

There is possible to estimate the average costs of higher herd recovery (higher cow culling) due to mastitis (according to data in Table 3) to 1800 CzC (21% of total losses) and their variability to 365 – 4525 CzC per one case of occurrence. Their amount is mainly influenced by the intensity of cow culling, sales of cull cows and production costs (by price) of pregnant heifers which are entered into the herd (herd recovery). The annual number of culled cows with udder disease accounted for example 12.4% in France (Seegers et al., 1998), 26% in Sweden (Nielsen, 2009), 3.8 and 10.4% in New Zealand (Xu and Burton, 2003; Lacy-Hulbert et al., 2006), 16.0, 16.2 and 30.3% in Germany (Römer, 2012; Rudolphi, 2012; Wangler et al., 2008), 12.2% in Austria (Fürst, 2010), 15.0% in the USA (Jones, 2009), 10.1% in England (Esslemont and Kossaibati, 1997) etc. In the CR mastitis in the last few years is the cause of cow culling around 9% of the total culled dairy cows (Kvapilík et al., 2014). Also prices of culled dairy cows show the relatively large variability among EU states. For example in the period from January 2012 to June 2014 was one kg of cow carcass weight purchased for CzC 62 in the CR and for CzC 71.25, 78.75 and 76.75 in Austria, Germany and EU-27 (AgrarMarkt Austria, 2014). When carcass weight was 300 kg the revenues per slaughter cow were by 2775, 5025 and 4425 CzC lower in the CR as compared to those countries.

Culling of cows with chronic inflammation of the mammary gland is often regarded as an effective method. For example Mustafa (2003) confirms this opinion because in most of herds only 6 – 8% of cows show from 40 to 50% of all clinical mastitis. A similar view state also Jones (2009), Leslie (1995), Down et al. (2013), Hogeveen et al. (2011), Schroeder (2012), Kitchen (2013) and other authors. Also Zelinková (2014) considers a treatment of cows with SCC over 1000 10^3. ml^{-1} as economically inefficient. On the other hand Dekkers et al. (1996) are highlighting the fact that the culling of dairy cows with high milk SCC can be economically more demanding than any penalty for worse milk quality.

The costs of drugs, veterinary examination and work

Veterinary performances are well-identifiable items. It means costs of medicines, veterinary sample analysis and work of veterinarians. Therefore, these are included in most of calculations of economic losses caused by inflammation of the mammary gland of cows. There is possible to estimate their variability to 200 – 2900 CzC (Table 3). Then the average is 1350 CcC per one case of incidence. It is equal to 16% of total average economic loss. The amount of these items depends on the number of sick cows, prevention and treatment programs and procedures, the price of drugs etc. Due to the benefits of prevention and treatment of mastitis these expenditures are mosty efficient.

The labour consumption

The costs of labour consumption associated with the care and treatment of mastitis in suffered dairy cows are presented in Table. 3, in „other items“. There is generally reported labour consumption in the range from 1 to 4 hours and labour costs between 19 and 34 € (475 – 850 CzC) per one case of the occurrence of mastitis in the literature (Huijps et al., 2008; Tischer, 2011). Higher consumption of the working time is analyzed in the details under New Zealand conditions (Lacy-Hulbert et al., 2006). There is accounted also with the higher consumption of time by 5 minutes more per milking during cure and by 2 minutes more in the period of excluding of milk from sale per one dairy cow with clinical mastitis. If there are three treatments and eleven milkings in the withdraval period so there is higher time consumption by 37 minutes per cow and occurrence case. It is equal to 9.9 NZ$ (168 CzC) per case at an hourly rate of NZ$ 16 [1 NZ$ (New Zealand dollar) = 17.0 CzC]. Next consumption of time (9.5 and 20.0 NZ$, it is equal to 160 and 360 CzC) is calculated for two variants of separation of dairy cows with mastitis. Then a higher consumption of working time to the occurrence of clinical mastitis demands higher cost by 19.3 and 29.9 NZ$ (328 and 508 CzC). The authors did not include the costs of higher time consumption associated with management of mastitis cow herd into this calculation.

Penalty of the purchase milk price

Penalties for the worse quality of raw cow milk which is sold for processing may be the next economic loss caused by inflammation of the mammary gland. The reduction of the farmer milk price follows after finding (after analysis of bulk milk samples) that there have not been kept the valid limits of quality which are set by relevant EU standards, eg. Council Directive 92/46 (1992), European Parliament and Council Regulation 853/2004 (2004), 845/2004 (2004) and others. The national legislation standards, such as Regulation

203 (2003), and the agreements between the customer (dairy factory or marketing cooperative) and suppliers of raw milk (farmers) are derived from above mentioned regulatios. The penalties of the purchase price, or loss of premiums (extra money), which are in relation to mastitis are linked mainly with SCC and partly with lower milk fat and protein content, RIS occurrence and higher TCM. This part of economic losses is included in relevant estimations only exceptionally.

The systems of raw milk quality evaluation and methods of purchase milk price construction are changed according to consumer demands on increasing of food security. Like ten years ago (Kvapilík, 2005), the worse indicators of quality and a lower contents of major milk constituents are punished by penalties from purchase milk price. The above-average milk quality is linked with bonuses (premium pay, extra money) which are paid to purchase (farmer) milk price. A similar system which takes into account the quality of milk as in Bavaria and other German countries (Table 4) is implemented also in some dairies in the CR as a result of globalization of milk purchase and processing. There are implemented different systems of penalty for higher SCC or preference for lower SCC as compared to demand of relevant legislation in various countries.

For instance, the Arla Foods (2014) dairy company sanctions the bulk milk with SCC over 400 and 500 10^3.ml^{-1} by purchase price penalty about 4 and 10% (Table 5). Relatively complex system for raw milk quality evaluation sets for SCC value over 500 10^3.ml^{-1} in bulk milk penalty 3, 4 or CA$ 5 per 100 litres (approximately 0.57, 0.76 and 0.95 CzC per liter) in Ontario (Raw Milk Quality Program Policies, 2011; 1 CA$, Canadian dollar, = 19.0 CzC). Within the Swiss system (Reneau, 2007), there are applied the sanctions along the occurrence of SCC over 350 10^3.ml^{-1} in a bulk milk. The first month is free of penalties but 2nd, 3rd and 4th month the purchase price is reduced by 3.8, 7.6 and 15.2%. In the 5th month the price is reduced by 30% and the purchase is stopped in the next period. Two systems of bonuses and penalties for SCC in the bulk milk are used in Republic of South Africa (Banga et al., 2014) (Table 6). As one of the penalties for SCC over 400 10^3.ml^{-1} and TCM over 100 10^3.ml^{-1} in the bulk milk is applied the reduction of the purchase milk price by 0.3 and 0.7 CzC per litre in the CR (Milk purchase contract, 2014).

The current contents of fat and protein in sold milk are usually taken into account by extra money or penalties from the purchase price in the relation to the determined threshold. For this purpose the special prices are fixed for fat and

Table 4
Quality classes and farmer milk prices in Bavaria

Class, values	Indicator	Values	Milk price change[1)]	
			cent/kg	CzC[2)]/kg
S (super)	TCM	≤ 50 10^3.ml^{-1} [3)]	+0.5 – +1.0[4)]	+0.13 – +0.25[4)]
	SCC	≤ 300 10^3.ml^{-1} [2)]		
I	TCM	≤ 100 10^3.ml^{-1} [3)]	x	x
II		> 100 10^3.ml^{-1} [3)]	-2 (at least)	-0.50 (at least)
Maximal values	SCC	400 10^3.ml^{-1} [3)]	-1 (at least)	-0.25 (at least)
	MFPD	-0.515 °C	exclusion of supply[5)]	
x	RIS	positive case	-5[6)]	-1.25[6)]

Güteprüfung der Anlieferungsmilch durch den Milchprüfring Bayern e.V., 2011; Huber, 2014; 1) extra money (+) or penalty (-); 2) 1 € = 25 CzC; 3) moving average; 4) extra money, for instance dairy factory can determine in mentioned height; 5) at demonstration of added water; 6) milk with RIS is exluded of supply, milk price penalty during the current month per each positive finding; 7) MFPD = milk freezing point depression; 8) RIS = residues of inhibitory substances (antibiotica drugs)

Table 5
SCC and farmer milk price in Arla Food

The extra money (or penalty) and farmer milk price (in %) at SCC in the bulk milk (10^3.ml^{-1})				
to 200	201 – 300	301 – 400	401 – 500	over 500
+2	+1	0	-4	-10

Arla Foods, 2014.

protein units. As it is seen from Table 7, their amount shows also relatively large variability among milk buyers. There is possible to estimate the impact of milk quality decrease on its purchase price due to cow mastitis at 0.63 CzC per litre which is equal to 6.6% of the current average price of milk (about CzC 9.50 per litre) from model calculation in the Table 8.

Table 6
SCC and farmer milk price in South Africa Republic

Variant „A“		Variant „B“	
SCC 10^3.ml^{-1}	extra money (bonus) and penalty (ct[1)]/liter)	SCC 10^3.ml^{-1}	extra money and penalty (ct[1)]/liter)
under 400	+0.4/-10,000 SCC[2)]	under 350	+0.4/-10,000 SCC[2)]
400 – 500	0	350 – 400	0
over 500	-0.1/+10,000 SCC[3)]	over 400	-0.4/+10,000 SCC[4)]

Banga et al., 2014; 1) 1 cent = approximately 0.0195 CzC; 2) for each SCC reduction by 10,000 under the set limit to the amount of the extra money 4 ct (around CzC 0.80) per liter of milk; 3) for each SCC increase by 10,000 over 500 10^3.ml^{-1} up to a total height of penalty 4 cents (around CzC 0.80) per liter of milk; 4) for each SCC increase by 10,000 over 400 10^3.ml^{-1} up to a total height of penalty 10 cents (around CzC 1.95) per liter of milk

Table 7
Prices of fat and protein unit[1)] for milk farmer price calculation in 2014

Source	State, dairy factory	Unit price (CzC[2)])		Price ratio P : F
		fat (F)	protein (P)	
Milchgeld – Anlageblatt, 2014	Austria[3)]	0.77	0.96	1 : 1.2
	FrieslandCampina	0.83	1.40	1 : 1.7
	Arla	1.19	1.52	1 : 1.3
LK Rheinland-Pfalz, 2014	MW Oberfranken	0.68	1.03	1 : 1.5
	Hochwald	0.63	1.25	1 : 2.0
	Schwälbchen[3)]	0.60	1.20	1 : 2.0
Milk purchase contract, 2014	CR – sales cooperative	0.65	0.90	1 : 1.4
x	mean	0.76	1.18	1 : 1.55

CR = Czech Republic; 1) standard fat content 4.0% (4.2%) and protein content 3.40% abroad, in CR 3.7% of fat and 3.4% of protein; 2) 1 € = 25 CzC; 3) in 2014 and in last years

Table 8
Model calculation of SCC increase effect on farmer milk price

Indicator			Unit	SCC (10^3.ml^{-1}) in bulk milk		
				200	350	500
Content in milk	fat		%	4.20	4.10	3.90
	protein			3.40	3.39	3.37
Milk price penalty[1)] for	lower content	fat	CzC/liter	0	0.07	0.20
		protein		0	0.01	0.03
	higher SCC			0	0.05	0.30
Extra money loss for „Q“ class			CzC/liter	0	0.05	0.10
price penalty in total			CzC/liter	0	0.18	0.63
			%[2)]	0	2.1	6.6

1) 0.65 CzC and 0.9 CzC for milk fat and protein unit; 2) from price (without extra money and penalties) 9.5 CzC per liter of milk

From this loss there are accounted around: 48% for higher SCC; 32% for lower fat content; 15% for loss of the premium for higher milk quality (extra charge for the class „Q" or „S"); 5% for lower protein content. Also this loss item caused by mastitis varies in dependence on type of purchase price construction and assessment of main milk constituents in a wide range like other items. The system of penalties and bonuses which is used in Bavaria (Kvapilík and Syrůček, 2013) (Table 9) is comparable somewhat with the data in Table 8. This system is valid also for row of Czech producers who sell their milk for processing to this country.

The premiums to price for milk quality were higher on average than penalties (by 0.03 – 0.28 CzC) within the SCC range 100 – 250 10^3.ml^{-1}. Than the penalties were higher, compared to bonuses (by 0.19 – 0.53 CzC per kg) at SCC values over 250 10^3.ml^{-1}. According to above mentioned facts, there is possible to estimate an impact of cow disease by mastitis on purchase milk price decreas by 0.4 – 0.7 CzC and on average by 0.65 CzC per liter of milk. According to Reichert (2009) light mastitis can be cured in three to four days after and acute mastitis during treatment taking from 10 to 12 days. In early start of treatment the SCC can be reduced to normal values within 12 days. Mastitis can affect the price of milk mostly for 30 – 50 days which means approximately 750 litres of milk at annual milk yield 7500 litres per cow as taking into account the time to detect of problems with the health status of the mammary gland, sampling intervals for analysis and systems of milk price construction. This is possible to estimate the average loss due to the lower price of milk to 500 CzC per incidence of mastitis at range from 300 to 550 CzC.

The estimation of total losses and their items caused by mastitis

From the literature and other published documents the costs of clinical mastitis can be estimated at 9000 CzC under CR conditions. On this item participate (Table 10 and Figure 1): 53% because of lower revenues from the sale of milk; 20% because of higher herd recovery (cow replacement); 14% of costs on milk sample analyses, drugs and cow cure; 7% of labour costs spent on treatment of sick cows; 6% of reduction of the purchase milk price due to lower fat and protein content and lower milk quality. The other causes of economic losses which are cited in some literature (as low fertility, susceptibility to other production diseases, embryo survivability, etc.) usually result in a decreasing of milk yield and therefore these are reflected in lower revenues from the milk sale.

As a result of various factors (as number of cows with mastitis, the course of the disease, the causative agent of ill-

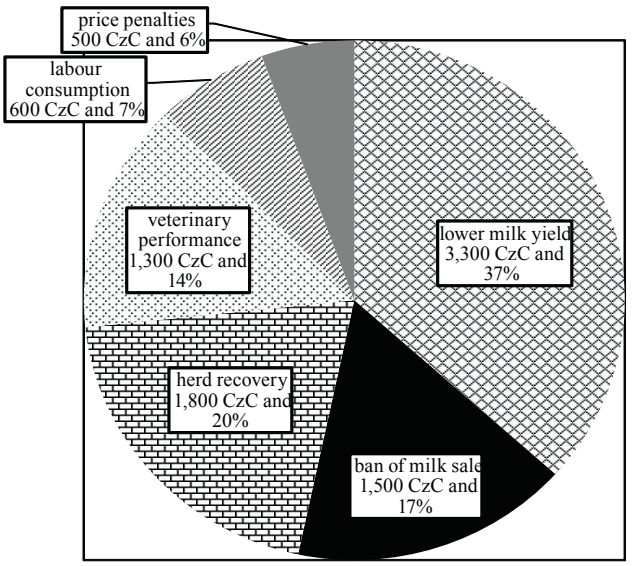

Fig. 1. The costs and losses caused by mastitis (per case, 100% = 9,000 CzC)

Table 9
Extra money and penalties for milk quality in Bavaria (CzC[1)]/kg of milk)[2)]

Extra money (+) penalty (-)		SCC in bulk milk (10^3.ml^{-1})					
		100	150	200	250	300	350
protein		+0.01	+0.03	+0.02	-0.01	-0.05	-0.12
fat		+0.03	+0.03	0.0	-0.09	-0.20	-0.37
„S" class		+0.22	+0.22	+0.20	+0.15	+0.08	0.0
class II		0	0	-0.01	-0.02	-0.02	-0.04
RIS		0	-0.0002	-0.0003	-0.0004	-0.0005	-0.0006
in total	CzC	+0.26	+0.28	+0.21	+0.03	-0.19	-0.53
	%[3)]	+2.7	+2.9	+2.2	+0.3	-2.0	-5.6

Kvapilík and Syrůček, 2013; 1) 1 € = 25 CzC; 2) the model calculation based on the analysis of milk samples in the Bavarian laboratories from 2009 to 2013; 3) from the price of milk (excluding extra money (bonuses) and penalties) CzC 9.5 per kg

ness, milk yield, the system of prevention and treatment of mastitis, the costs on rearing of cows and their main items, milk prices and prices of slaughtered cows, price of heifers which are entered into the herd and others) there is possible to estimate the variations in losses from 4000 to 18 000 CzC per occurrence of clinical mastitis. The amount of the loss on the cow of average herd state changes according to the proportion of cows infected with mastitis (Figure 2). There is shown in Figure 2 a model calculation of losses according to data in the Table. 10. The minimum losses are estimated as 45% and maximum losses as 100% of the average losses. For instance there is possible to estimate the economic loss per each cow (healthy and ill) of herd at 1800, 3155 and 4500 CzC at proportions of mastitis cows 20, 35 and 50%.

According to various authors (Kvapilík, 2014) the clinical mastitis attacks 17 – 48% of dairy cows per year, annual average can be estimated approximately at 30 – 35%. The proportion of subclinical mastitis is significantly greater than clinical. There

Table 10
Estimation of losses by mammary gland inflammations of milked cows in the Czech Republic (CR)

Loss type		CzC/mastitis case			CzC/cow (% of ill)		
		average		from - to	20	35	50
		CzC	%	CzC	CzC		
Milk	Lower milk yield	3 300	37	1 500 – 7 000	660	1 155	1,650
	sale ban	1 500	17	200 – 2 500	300	525	750
	total loss	4 800	53	2 800 – 8 700	960	1 680	2,400
Higher herd recovery		1,800	20	500 – 4 500	360	630	900
Veterinary performances[1)]		1,300	14	300 – 2 400	260	455	650
Higher labour consumption		600	7	400 - 800	120	210	300
Farmer price penalties		500	6	300 - 600	100	175	250
Total losses		9,000	100	4 000 – 18 000	1 800	3 150	4 500

1) Costs on drugs, veteriary examination and work.

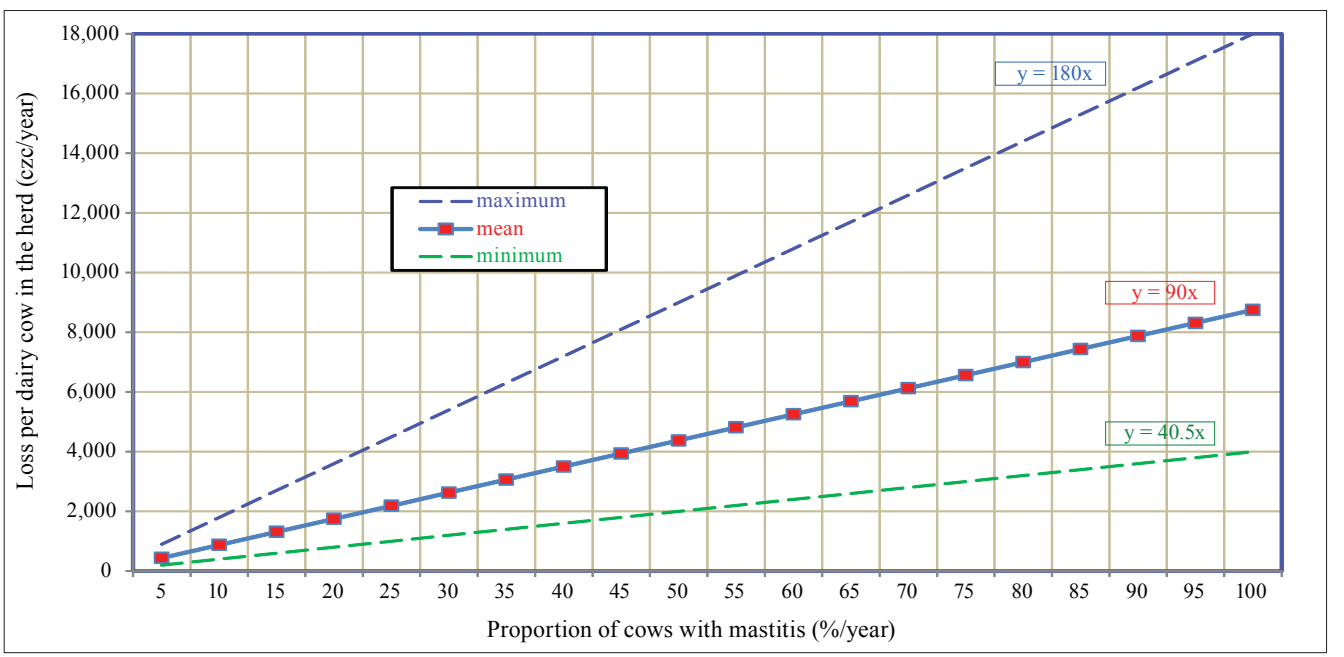

Fig. 2. Proportion of cows with mastitis in the herd and economic losses (estimation)

can be reached the total economic loss caused by mastitis about CzC 1170 million a year in the case that there would be sicken for clinical mastitis 35% (130 thousands) of current dairy cow herd (373 thousands) in the CR. The loss of CzC 9,000 per cow with mastitis and 3140 CzC per dairy cow of herd is equal to revenues for the sale of 950 and 330 litres of milk at the current farmer price of milk CzC 9.50 per litre. Proportion increasing of cows with mastitis by 1% would result in an increase in annual economic losses by next 38.5 millions of CzC.

Milk produced in the CR fulfills the quality indicators and requirements of the applicable EU and CR legislation in most cases and therefore its quality can be described as good. Yet, it is evident (from Figure 3) that the CR milk samples analyzed in Bavaria laboratories (Milchprüfring Bayern e. V., 2014) had higher SCC mean by 89 $10^3.ml^{-1}$ and 54% than Bavarian milk and by 114 $10^3.ml^{-1}$ and 71% than Austria milk. These SCCs had an impact on the proportions of month samples with SCC higher than 400 $10^3.ml^{-1}$ as maximum acceptable level. In the period 2009 – 2013 the SCC ≤ 400 $10^3.ml^{-1}$ was not reached in 4.6 – 7.4% of cases of milk samples from CR. In Bavaria it was only 0.9 – 1.0% and in Austria 0.9 – 1.4% of milk samples (Figure 4). This international comparison shows on current necessity of mastitis occurrence decreasing in the CR. It is relevant both in terms of improvement of economy and international position of rearing of dairy cows and in terms of increasing of quality and safety of milk products.

Mastitis prevention and treatment

Due to the prevalence of mastitis on a global scale and economic losses which are linked with inflammation of the mammary gland of dairy cows there is paied the extraordinary attention to their prevention and therapy. Many authors are in agreement on the idea that prevention is better than treatment. Among the preventive measures are normally declared: regular monitoring and evaluation of the health status of the mammary gland; technology and hygiene of milking; teat disinfection after cow milking; preparation of cow for dry period; cow nutrition; timely and appropriate treatment of symptoms of clinical mastitis; culling of cows with chronic mastitis which are unresponsive to treatment and others. These and similar measures are provided by Hejlíček et al. (1987), Leslie (1995), Bagley (1997), Crist et al. (1997), Rysanek and Babak (2005), Seydlová (2010, 2012), Looper (2012), Winter and Fehlings (2013), Illek (2014) and others.

For instance Schroeder (2012) adverts to the high efficiency of the preventive anti-mastitis program. He reported about reduced losses from the sale of milk by 136 US$ (2.850 CzC) at the costs of preventive measures US$ 24. These correspond to 500 CzC of which 210 on teat disinfection, 85 for medication of dry cows and 210 CzC for paper towels. This amount is equal to the benefit of prevention of US$ 112 (2.355 CzC). Also according to Kron (2002) calculation, there is apparent benefit of preventive treatment of cow group against

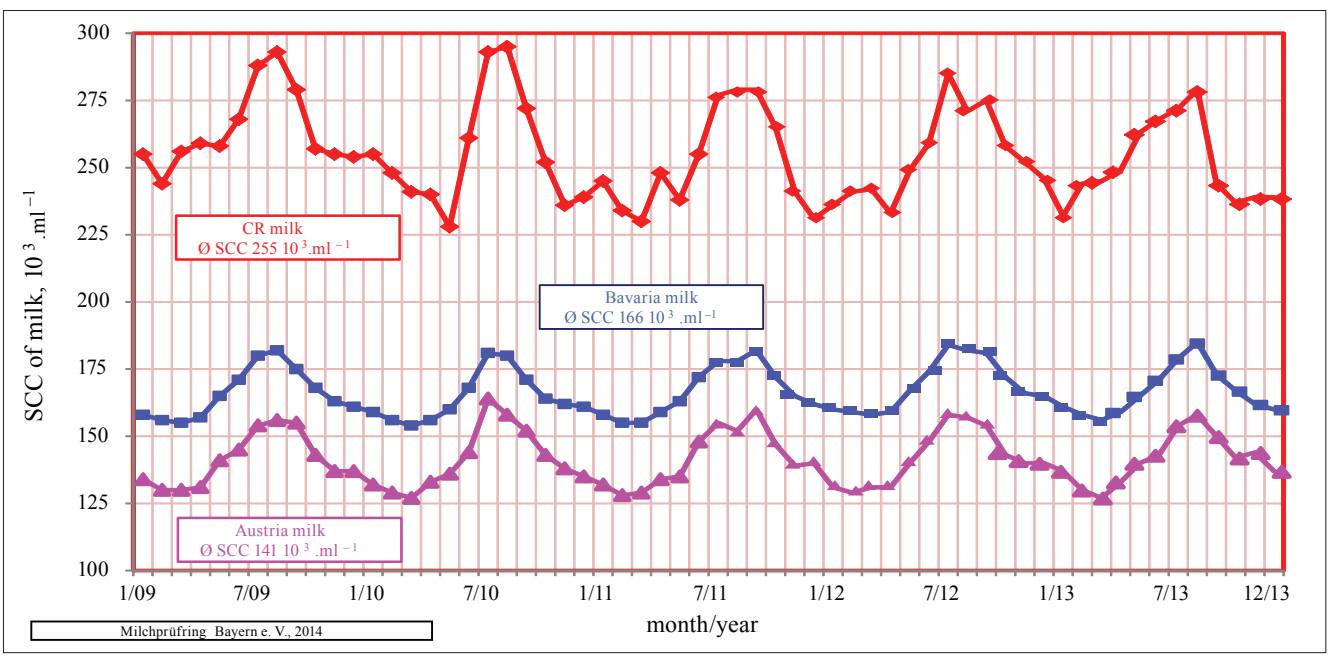

Fig. 3. Somatic cell count (SCC) in milk samples analyzed in Bavaria

mammary gland inflammation in the amount 136 € (3.400 CzC) per cow during the first 100 days of lactation (Table 11). The fact that not all preventive measures must be economically efficient pointed Hogeveen et al. (2011).

There were only six economically efficient preventive measures according to benefit calculations of 18 farm measures. It was reached on a farm with 65 dairy cows in the Netherlands: 8500 kg milk yield per cow and year; milking parlour with 12 stands; SCC 200 10^3.ml^{-1} in bulk milk; mastitis incidence in 30% cows per year. There were included measures from the hifhest to the lowest positive nett benefit as follows: blanket use of dry-cow therapy; keeping cows standing after milking; back-flushing of the milk cluster after milking a cow with clinical mastitis; application of treatment

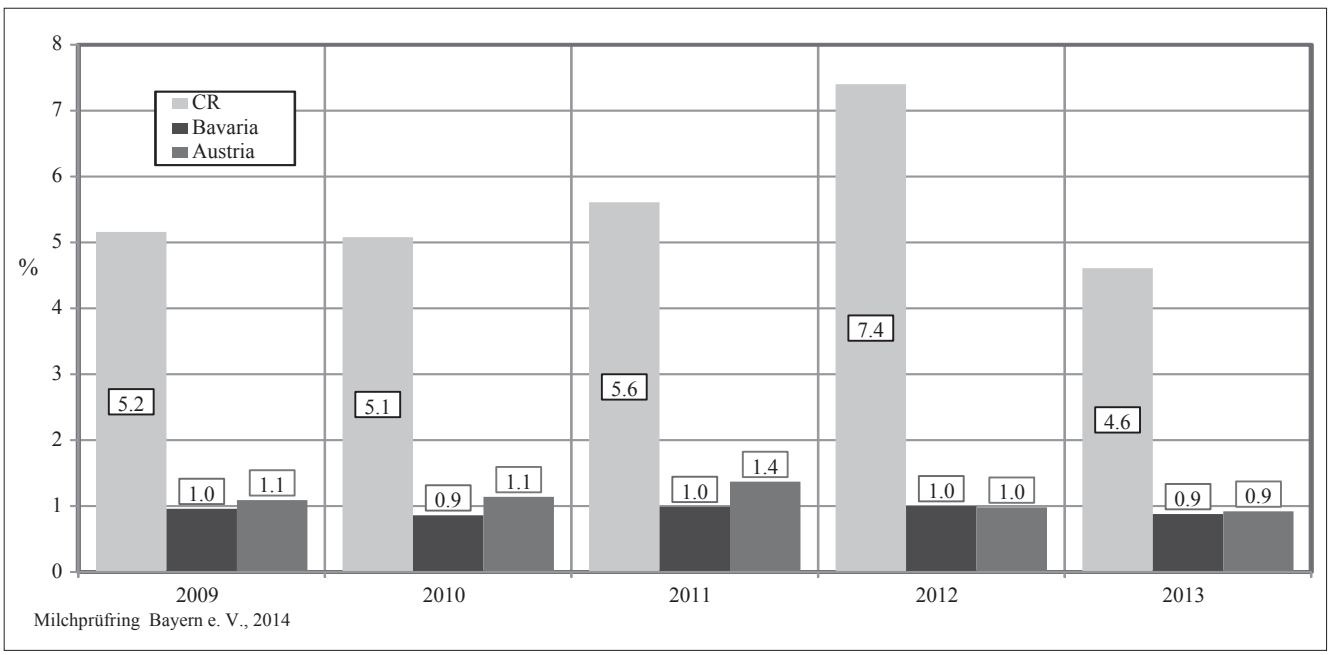

Fig. 4. Somatic cell count (SCC) over 400 10^3.ml^{-1} in milk samples analyzed in Bavaria

Table 11
Calculation of preventive measures against mammary gland inflammations

Item	Indicator	CzC[1)] per experimental group (n = 33)	CzC[1)] per experimental group (n = 36)
Sales	milk for the first 100 lactation days	33 × 1 852 kg × 7.25 CzC = 443 090 CzC	36 × 1 473 kg × 7.25 CzC = 385 455 CzC
	culled dairy cows	4 × 10 000 CzC = 40 000 CzC	7 × 10 000 CzC = 70 000 CzC
	in total	483 000 CzC	455 455 CzC
Costs	cow treatment	33 × 575 CzC = 18 975 CzC	x
	additional therapy[2)]	1 × 750 CzC = 750 CzC	8 × 750 = 6 000 CzC
	herd completion[3)]	4 × 25 000 CzC = 100 000 CzC	7 × 25 000 CzC = 175 000 CzC
	in total	119 725 CzC	181 000 CzC
Balance, 100 lact.[4)] days	per group	363 275 CzC	274 455 CzC
	per dairy cow	11 000 CzC	7 600 CzC
	difference[4)]	+3 400 CzC	-3 400 CzC

Kvapilík and Syrůček, 2013; 1) 1 € = 25, CzC; 2) combined therapy with parenteral penethamate-hydriodide and locally by cefacetrile; 3) by heifers for culled dairy cows; 4) lactation

protocol; washing dirty udders; the use of milkers‘ gloves during milking. All these measures were relatively inexpensive. In general, the reduced losses from the preventive measures are relatively low, varying between € 8 and 36 (200 – 900 CzC) per cow per year. The preventive measures with the most negative nett benefit were measures with high additional expenditure, such as back-flushing the milk cluster after milking cows with subclinical mastitis, and milking cows with subclinical mastitis last. The above examples show that early prevention and treatment of cow mastitis with respect to the specific conditions of the herd can significantly reduce the production and economic losses associated with the illness.

Conclusion

The inflammations of the mammary gland are the most widespread and economically demanding diseases among all production diseases in dairy cows. Subclinical and clinical mastitis occur in varying intensity almost without exception in all herds. Therefore, prevention and therapy should be regular and permanent part of herd management as feeding and milking. The condition of prevention and early initiation of any treatment is necessary current knowledge of the health status of the mammary gland of cows. It is possible by SCCs in milk which is investigated in regular intervals in the official milk recording with sufficient reliability and mostly under reasonable costs. As for another production illnesses also for mastitis is valid known principle that the therapy is more successful when the interval between the diagnosis of the disease and starting of its treatment is shorter.

At relatively large variability it is possible to estimate that one case of mastitis occurrence can cause the economic loss of around 9000 CzC. There are involved above all lower revenues from the sale of milk (53%), higher costs on herd recovery (20%) and costs for drugs and cure (14%). The reduction of mastitis incidence and decrease of SCC in milk could improve the economic results of dairy cow rearing and increase the competitiveness of CR farmers as compared to milk producers in other EU countries.

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References

AgrarMarkt Austria, 2014. http://www.ama.at/

Anonym, 1996. Current concepts of bovine mastitis. In: National Mastitis Council, Inc., *Madison*, WI.

Anonym, 2008. Mastitis. Dippen Sie schon? So bekämpfen Sie eine Mastitis effektiv. *Landwirt*, **6**: 6-7.

Arla Foods, 2014. Kvalitetsprogrammet Arlagården®. http://www.arla.com/Global/responsibility/pdf/arlagarden/Kvalitetsprogrammet-Arlagaarden_DK.pdf

Asseldonk van, M. A. P. M., R. J. Renes, T. J. G. M. Lam and H. Hogeveen, 2010. Awareness and perceived value of economic information in controlling somatic cell count. *Vet. Rec.*, **166**: 263-267.

Bagley, C., 1997. Mastitis Prevention Program. In: *Utah State Univ.*, electronic publishing, AH/Dairy/02, Logan. http://extension.usu.edu/files/publications/factsheet/AH_Dairy_02.pdf

Banga, C. B., F. W. C. Neser and D. J. Garrick, 2014. The economic value of somatic cell count in South African Holstein and Jersey cattle. *S. Afr. J. Anim. Sci.*, **44** (2): 173-177.

Brightling, P., G. A. Mein, J. Malmo and D. P. Ryan, 1998. Countdown Downunder: Farm Guidelines for Mastitis Control. *Dairy Research and Development Corporation*, Melbourne.

Council Directive 92/46, 1992. Health Rules for the Production and Placing on the Market of Raw Milk, Heat-Treated Milk and Milk-Based Products, 16 June, 1992.

Crist, W. L., R. J. Harmon, J. O'Leary and A. J. McAllister, 1997. Mastitis and its control. In: Cooperative Extension Service, ASC-140, *University of Kentucky.*

Czech National Bank, 2014. http://www.cnb.cz/cs/index.html

Dekkers, J. C. M., T. Van Erp and Y. H. Schukken, 1996. Economic benefits of reducing somatic cell count under the milk quality program of Ontario. *J. Dairy Sci.*, **79** (3): 396-401.

Down, P. M., M. J. Green and C. D. Hudson, 2013. Rate of transmission: A major determinant of the cost of clinical mastitis. *J. Dairy Sci.*, **96**: 6301-6314.

Dyson, R., 2003. Cost of clinical mastitis dramaticaly increasis. Dairy Australia. www.petalia.com.au/Templates/StoryTemplate_Process.cfm?specie=Dairy&story_no=210

Egger-Danner, Ch., 2008. Gesundheitsmonitoring Rind – ein innovatives Projekt für die Viehwirtschaft. ZuchtData, Wien, 14. Wintertagung für Grünland- und Viehwirtschaft, Aigen im Ennstal. https://www.google.cz/?gws_rd=ssl#q=Gesundheitsmonitoring

Esslemont, R. J. and M. A. Kossaibati, 1997. Culling in 50 dairy herds in England. *Vet. Rec.*, **140**: 36-39.

Fürst, Ch., 2010. Sind schöne Euter auch gesund? In: ZuchtData, Fleckvieh Austria, 2, 2010, pp. 4-5.

Güteprüfung der Anlieferungsmilch durch den Milchprüfring Bayern e.V., 2011. Guetepruefung-Info Vers./Stand: 05/11.04.2011. https://www.mpr-bayern.de/

Harms, J., 2013. Betriebswirtschaftliche Aspekte zur Eutergesundheit und Vorstellung eines neuen Forschungsprojektes. 2. Roboter Stammtisch von LKV und LFA, Güstrow. http://www.lkv-mv.de/formulare/AMS_2_Feb2013.pdf

Heber, I., 2013. Investitionen in die Tiergesundheit - was darf sie kosten? Sächsischer Milchrindtag, Groitzsch. http://www.landwirtschaft.sachsen.de/landwirtschaft/download/ Ingo_Heber.pdf

Hejlíček, K. et al., 1987. Cattle Mastitis. SZN Prague: 201 (Cz).

Hogeveen, H., K. Huijps and T. J. G. M. Lam, 2011. Economic aspects of mastitis: new developments. *New Zeal. Vet. J.*, **59** (1): 16-23.

Huber, L., 2014. Milch-Güteverordnung (MilchGüV). In: Milchprüfring Bayern e.V., 2014. http:// www.lfl.bayern.de/iem/milchwirtschaft/026702/

Huijps, K., T. Lam and H. Hogeveen, 2008. Costs of mastitis: facts and perception. *J. Dairy Res.*, **75**: 113-120.

Illek, J., 2014. Cattle mastitis. In: Proceedings from Seminar Cattle Mastitis, *Czech Buiatric Society*, Střítež, pp. 5-26. (Cz).

Jones, G. M., 2009. Guidelines to culling cows with mastitis. In: Milk Quality & Milking Management, Virginia State, Petersburg.

Jones, G. M. and T. L. Bailey, 2009. Understanding the Basics of Mastitis. Virginia Cooperative Extension, *Virginia State University*, USA, publication No. 404-233, pp. 1-7.

Kitschen, S., 2013. Treat or cull: What are the options for a chronic mastitis cow? In: Progressive Dairymann. http://www.progressivedairy.com/

Kossaibati, M. A. and R. J. Esslemont, 1997. The costs of production diseases in dairy herds in England. *Vet. J.*, **154** (1): 41-51.

Kron, A., 2002. Mastitisbekämpfung rechnet sich. In: Tiergesundheit und Mehr. www.tier-gesundheitundmehr.de/archiv/themen.html

Krömker, V., 2007. Kurzes Lehrbuch Milchkunde und Milchhygiene. *Parey Verlag,* p. 232.

Kvapilík, J., 2005. Construction of milk purchase prices in Czech and west European dairy factories. In: VÚŽV Uhříněves, *ČMSCH*,Prague, ISBN 80-86454-60-6, p. 78 (Cz).

Kvapilík, J., 2014. Mastitis in dairy cows and production losses. *Veterinářství*, **64** (7): 550-560.

Kvapilík, J. and Z. Růžička, 2009. Estimation of losses by mastitis. *Veterinářství*, **2**: 104-108 (Cz).

Kvapilík, J. and J. Syrůček, 2013. Somatic cell count and other milk quality indicators. *Mlékařské Listy*, **24** (137): 10-15 (Cz).

Kvapilík, J. et al., 2014. Annual Report - Cattle rearing in the Czech Republic in 2013. *ČMSCH, SCHČSS, SCHČS, ČSCHMS*, Prague (Cz).

Lacy-Hulbert, J. et al., 2006. The cost of mastitis. Dairy Insight Research 2005/2006, Final Report.

Leslie, K. B., 1995. Somatic Cell Counts: Interpretation for Individual Cows. In: Ontario Factsheet. Agdex, 410/662.

LK Rheinland-Pfalz, 2014. Aktuelles zum Milchmarkt. http://www.lwk-rlp.de/

Looper, M., 2012. Reducing somatic cell count in dairy cattle. In: Division of Agriculture Research & Extension, University of Arkansas System, FSA4002. http://www.uaex.edu/publications/pdf/fsa-4014.pdf

Lührmann, B., 2013. Erkrankungen bei Milchkühen – was kostet eine Mastitis? Vortrag Milch-erzeugertag, Landwirtschaftskammer Niedersachsen. http://www.lwk-niedersachsen.de/

Malkow-Nerge et al., 2014. Kosten und Ertragsverluste einer klinischen Mastitis je Kuh. In: PathoProof™- Mastitis PCR-Test. http://www.lkv-we.de/PathoProof-_Mastitis_PCR-Test.html

Milchgeld – Anlageblatt, 2014. Milchpreis für höchste Qualitätsstuffe - ab 1. Juni 2014. In: MGN Milchgenossenschaft NÖ, Baden. http://www.mgn.at/rundschreiben/

Milchprüfring Bayern e. V., 2014. Informationen und Statistiken. https://www.mpr-bayern.de/

Mitev, J., Z. Gergovska, T. Miteva and T. Penev, 2011. Influence of lameness on daily milk yield, lactation curve and body condition score during lactation in Black-and White cows. *Bulg. J. Agric. Sci.*, **17** (5): 704-711.

Mustafa, A., 2003. Mastitis in dairy cows. In: Dairy Cattle Production 342-450A, *MacDonald Campus of Mcgill University*, Faculty of Agricultural & Environmental Sciences, Department of Animal Science.

Nielsen, Ch., 2009. Economic impact of mastitis in dairy cows. Doctoral thesis, *Acta Universitatis Agriculturae Sueciae*, Uppsala, 29.

Raw Milk Quality Program Policies, 2011. Dairy Farmers of Ontario, November 1. https://www.milk.org/corporate/pdf/Publications-RawMilkPolicyBook.pdf

Regulation (EC), 2004. No 853/2004 of the European Parliament and of the Council, 29 April, 2004, Specific Hygiene Rules for Food of Animal Origin. *Off. J. Europ. U.*, L **139/55**.

Regulation (EC), 2004. No. 854/2004 of the European Parliament and of the Council, Specific Rules for the Organisation of Official Controls on Products of Animal Origin Intended for Human Consumption. *Off. J. Europ. U.*, **L 139**.

Regulation No. 203, 2003. Veterinary demands on milk and milk products. In: Call of Laws, part 73, June 30, 2003, (Cz).

Reichert, P., 2009. Allicin für Tiere. http://www.allicincare.com/

Reiterer, R. and T. Prünster, 2007. Eutergesundheit. Berufausbildung, Bergbauernberatung. Provinz Bozaen – Südtirol.

Reneau, J., 2007. How do the Swiss produce the world's best quality milk? In: Extension of Univ. Minessota. http://www.extension.umn.edu/agriculture/dairy/

Römer, A., 2012. Wie lange soll eine Kuh leben? In: Untersuchungen zur Nutzungsdauer und Lebensleistung. 22. Hauptversammlung des LKV Sachsen-Anhalt e.V ., Cobbelsdorf.

Rudolphi, B., 2012. Eutergesundheit – wesentlicher Faktor der Herdenökonomie. In: 30. Wissenschaftliche Fachtagung, Landesforschungsanstalt f. Landwirtschaft und Fischerei, Mecklenburg-Vorpommern. http://www.lkv-mv.de/formulare/ft30_6.pdf

Rüsch, P., 2000. Wirtschaftliche Bedeutung – was kostet Mastitis? In: M. Walkenhorst (Ed.) Mastitis: Kein Wundermittel gegen die Kuhkrankheit Nummer eins. *Bio Aktuell*, 9/2000.

Rysanek, D. and V. Babak, 2005. Bulk tank milk somatic cell count as an indicator of the hygiene status of primary milk production. *J. Dairy Res.*, **72**: 400-405.

Schroeder, J. W., 2012. Bovine mastitis and milking management. In: Mastitis Control Programs. http://www.ag.ndsu.edu/pubs/ansci/dairy/as1129.pdf

Seegers, H., F. Beaudeau, C. Fourichon and N. Bareille, 1998. Reasons for culling in French Holstein cows. *Prev. Vet. Med.*, **36**: 257-271.

Seydlová, R., 2010. Milk hygienic quality in organic herds. *Mlékařské listy*, **123**: VII-X (Cz).

Seydlová, R., 2012. Milk quality indicators: Somatioc cell count. In: E. Samková et al. (Ed.) Milk: Production and Quality. *České Budějovice*, JU ZF, ISBN: 978-80-7394-383-7: 128-140 (Cz).

Tischer, M., 2011. Strategische Mastitisbekämpfung in der Praxis. In: Seminar Zucht auf Eutergesundheit beim Rind. http://zar.at/Downloads/ZAR-Seminar.html

Tschischkale, R. and T. Peters, 2006. Akute Mastitis des Rindes. Euterentzündung, Tiergesundheit und mehr: pp. 9-11.

Varlyakov, I., T. Penev, J. Mitev, T. Miteva, K. Uzunova and Z. Gergovska, 2012. Effect of lameness on the behavior of dairy cows under intensive production systems. *Bulg. J. Agric. Sci.*, **18** (1): 125-132.

Wangler, A. et al., 2008. Analyse der Abgangsursachen in ausgewählten Milchviehbetrieben Mecklenburg-Vorpommerns unter Einbeziehung einzeltierbezogener Behandlungen und Leistungen. In: Forschungsbericht 2/30, Landesforschungsanstalt für Landwirtschaft und Fischerei Mecklenburg-Vorpommern.

Winter, P., 2009. Praktischer Leitfaden Mastitis. *Parey Verlag*, Stuttgart.

Winter, P. and K. Fehlings, 2013. Aspekte zur therapie von mastitiden in der laktation und zum trockenstellen. *Der praktische Tierarzt*, **94** (6): 21-27.

Wolfová, M., M. Štípková and J. Wolf, 2006. Incidence and economics of clinical mastitis in five Holstein herds in the Czech Republic. *Prev. Vet. Med.*, **77** (1-2): 48-64.

Wolter, W. and T. Bonsels, 2013. Eutererkrankungen kosten viel Geld. AID infodienst Bonn. http://www.aid.de/allg/impressum.php

Xu, Z. Z. and L. Burton, 2003. Reproductive performance of dairy cows in New Zealand. In: Final Report of the Monitoring Fertility Project. Dairy, *NZ* Ltd.

Zelinková, G., 2014. Subclinical Mastitis. *Virbac* (Cz). http://www.virbac.cz/cl8.html

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