

ECONOMIC IMPORTANCE OF MILK TRAITS IN CZECH HOLSTEIN CATTLE UNDER VARIOUS MILK PAYMENT SYSTEMS ¹

Zuzana KRUPOVÁ ², Jiří MOTYČKA ³, Emil KRUPA ⁴, Monika MICHALIČKOVÁ ⁵

ABSTRACT

The impact of various pricing systems on the economic values of milk traits in Czech Holstein cattle was comprehensively evaluated. Milk yield, milk components, somatic cells score (SCS) and clinical mastitis incidences were evaluated under the average production and economic conditions of the year 2015. The flexible bio-economic model of the program package ECOWEIGHT 6.0.4 was used for calculation. Under the evaluated pricing systems marginal economic values of milk components ranged from 37.92 to 253.05 € and from 126.46 to 461.71 € per % of fat and proteins per cow per year, respectively. High variability was also found for economic importance of SCS (from –14.71 to 800.94 € pre score pre cow and per year). Marginal economic values for milk yield (0.103 € per kg) and clinical mastitis (83.86 € per incidence), both per cow and per year remained without the change over all pricing systems. To standardize the marginal economic values and to calculate the actual relative economic values of traits the actual genetic standard deviations are needed.

Key words: cattle, breeds, Czech Holstein, economic values, payment systems, milk traits, milk yield, milk components, SCS, clinical mastitis

1 INTRODUCTION

The abolition of milk quotas in 2015 has been caused stronger pressure on dairy sector in Europe. European Union supplies at a time when China has started to reduce its purchases and Russia has introduced an import ban have been resulted to the low prices for milk and dairy commodities (EC, 2015). For example, average milk price decreased by 17 % in the Czech Republic over the last year (MA CR, 2016). The bonuses defined in the milk pricing systems seem to be one solution to influence the milk price by farmers. Selection for milk production traits has traditionally received most emphasis in national breeding programs of dairy cattle in many countries (e. g. Hietala *et al.*, 2014; Komlósi *et al.*, 2010). Considering the actual selection strategy, breeding values and eco-

nomical values for milk fat and milk proteins (expressed both, in kg and in %) and somatic cell score (SCS) are the key breeding parameters for Czech Holstein cattle. Selection for reduced clinical mastitis incidence has not been yet included there in spite of the generally positive effect on animal welfare, product quality and economically sustainable farming (Krupová *et al.*, 2016).

The absolute economic values of milk production traits differed notably in the literature due to differences in pricing systems. The impact of various milk pricing systems on the economic weights for milk yield and fat and protein content in Holstein were investigated in the past (Wolfová *et al.*, 2007). In the Czech conditions, the milk pricing system has been still varied in high extension among the farms however the production and economic conditions of the breed have been changed from

¹ The work was supported by project MZERO0714 of the Ministry of Agriculture of the Czech Republic

² Institute of Animal Science, Přátelství 815, 104 00 Prague 10, Czech Republic, e-mail: krupova.zuzana@vuzv.cz

³ Holstein Cattle Breeders Association, Hradištko 123, 252 09 Hradištko, e-mail: motycka@holstein.cz

⁴ Same address as 2, e-mail: krupa.emil@vuzv.cz

⁵ Same address as 2, e-mail: michalickova.monika@vuzv.cz

this time. Therefore, the impact of various pricing systems applied in 2015 on the economic values of milk traits in Czech Holstein dairy cattle population using the bio-economic approach were comprehensively investigated in the study.

2 MATERIALS AND METHODS

2.1 PRODUCTION SYSTEM

Economic values of milk traits were calculated for purebred Holstein breed. Production system was treated as self-reproducing (breeding and commercial herds together). A classical indoor farming system with loose

for dairy herd presented in Table 1 corresponded to the population average obtained from own investigations on farms (unpublished data) and from the official resources (CMBC, 2015, 2016) for the year 2015.

2.2 PROFIT FUNCTION AND ECONOMIC VALUES

Economic efficiency of the production system was expressed as the present value of total profit per cow and per year entering a reproductive cycle (Wolfová *et al.*, 2007). Revenues were derived from milk, from sold animals (breeding heifers, calves, slaughtered cows and heifers), manure, and direct subsidies (0.007 € per kg of milk). Revenues from milk were a function of milk amount, fat and protein content, and somatic cell count.

Marginal economic value (economic importance) of trait l (ev_l) was calculated as the partial derivative of the profit function with respect to the trait:

$$ev_l = \left. \frac{\partial TP}{\partial TV_l} \right|_{TV_l = TV_{l,av}}$$

where TP was total profit per cow and year, TV_l was the value of trait l , and $TV_{l,av}$ was the trait mean within the population.

Relative economic value of trait l (in %) was calculated as proportion of absolute value of the standardized marginal economic value (i.e., marginal economic value multiplied by the genetic standard deviation) of trait l on the sum of the standardized marginal economic values of all evaluated traits. It was calculated to compare the

Table 1: The main input traits for Czech Holstein in 2015

Trait (unit)	Mean	Genetic standard deviation
Milk yield (kg) ¹	9 546	870
Milk fat percentage (%)	3.80	0.210
Milk protein percentage (%)	3.34	0.150
SCS (score) ²	4.387	0.083
Clinical mastitis (cases per cow and year) ³	0.98	0.080

¹ Milk yield defined as 305-day milk yield with constant fat and protein content averaged over all lactations

² Somatic cell score expressed as \log_2 (somatic cell count/100 000) + 3.

³ Clinical mastitis incidence expressed as the number of cases per cow and year at risk, averaged over all lactations.

housing of cows, selling (exporting) of surplus calves at weaning and selling of surplus pregnant breeding heifers was assumed. Markov chain approach was used to generate steady state of the dairy herd structure as described by Wolfová *et al.* (2007). The main input parameters

proportion of absolute value of the standardized marginal economic value (i.e., marginal economic value multiplied by the genetic standard deviation) of trait l on the sum of the standardized marginal economic values of all evaluated traits. It was calculated to compare the

Table 2: Characteristics of milk pricing systems (PS) for milk, fat and protein content and SCC¹

PS	Base milk price (€ kg ⁻¹)	Fat content		Protein content		SCC ¹	
		Intervals (%)	- / + ² (€ % ⁻¹)	Intervals (%)	- / + ² (€ % ⁻¹)	Intervals (1000 cells)	- / + ² (€ kg ⁻¹)
A	0.022	-	0.027	-	0.041	< 250 / ≥ 400	+0.049 / -0.20
B	0.058	-	0.022	-	0.040	≥ 400	-0.037
C	0.256	< 3.5 / ≥ 3.5	-0.007 / +0.014	< 3.0 / ≥ 3.0	-0.048 / +0.055	≥ 400	-0.037
D	0.273	< 3.6 / ≥ 3.8	-0.029 / +0.029	< 3.9 / ≥ 3.9	-0.062 / +0.044	≥ 400	-0.139
E	0.028	-	0.029	-	0.040	≤ 300	+0.004
F	0.304	< 3.4 / ≥ 3.7	-0.007 / +0.026	< 3.2 / ≥ 3.4	-0.007 / +0.044	≥ 240	-0.044
G	0.034	-	0.027	-	0.042	≥ 400	-0.044

¹ Somatic cell count measured in thousand of somatic cells per ml of milk as geometric average over the last 3 months period.

² - / + are penalties and bonuses for milk components intervals and for SCC. Value is not placed (-) in the Table when no interval was mentioned in the given PS (milk price linearly depended over the whole range of the milk components content). 1€ was set to 27.28 Czech Crowns.

economic importance of different traits. Considering the main aim of the study, only the traits related to milk price and milk payment system are presented here. Due to abolition of milk quota in April 2015 all calculations were done for the situations without quotas on milk yield and fat content. Detailed description of principles applied to calculate revenues, cost and economic values of the traits can be found in previous studies (e.g. Wolfová *et al.*, 2007; Krupová *et al.*, 2016) and in manual of the program package ECOWEIGHT (Wolf *et al.*, 2013).

2.4 MILK PAYMENT SYSTEMS

The actual milk payment systems provided by seven Czech dairies in the year 2015 were investigated in the study (Table 2). Two main indicators were considered as the inputs of the bio-economic model to simulate payment systems:

1. volume and system of penalties and/or bonuses for fat and protein content and for somatic cell count (SCC),
2. base price for milk plasma or base price for milk volume with the average components content

In the most of payment systems, average fat and protein content specified in the statistical statement of the Ministry of Agriculture of the Czech Republic (MA CR) for the given time period were referred to calculate average milk price. Therefore, when modelling the appropriate payment systems the content of milk components (3.84 % and 3.39 % for milk fat and proteins, respectively; MA CR, 2016) averaged over the year 2015 was taken into account.

Regarding the basic milk price it has not been directly defined in most of the payment systems except of the “C”, “D” and “F” where base milk price have been mentioned and it referred to the milk with the given fat and protein content and SCC. In other payment systems, base milk price has depended on the statistical statement (MA CR, 2016) and it referred to milk plasma. These specifics were set in the program to correspond to the

average price of milk in the Czech Republic in 2015 (MA CR, 2016) and to consider milk price difference in Czech Holstein breed (Wolfová *et al.*, 2007). In all variants of payment systems, average price per unit of milk finally calculated in the bio-economic model fully correspond to the value 0.276 € l⁻¹. The payment systems (listed in Table 2) were applied to the bio-economic model while other inputs for the breed remained constant. Name of dairies included into the evaluation remained anonymous due to confidentiality of data and without any impact on the main aim of the study.

The program EWDC (version 3.0.4) from the program package ECOWEIGHT 6.0.4 (Wolf *et al.*, 2013) was used to model production system and to calculate the economic values of traits. The model includes both deterministic and stochastic components. Most performances of animals are modelled as herd averages, but phenotypic variation in milk production, weight of heifers at mating (described by mean and standard deviation) and other traits are included. The model is non-integer (fractions of animals are allowed) and the cow herd size is given by a fixed number of cows calving per year in the dairy system.

3 RESULTS AND DISCUSSION

Marginal and relative economic values of milk traits calculated under the evaluated payment systems are shown in the Table 3 and Figure 1, respectively. Looking at the marginal economic values of milk traits over all of the pricing systems (shown in Table 3), variability of limits for milk components and SCC and associated penalties and bonuses for milk quality traits can be shown. These values varied between dairies from 0.007 € 1 %⁻¹ (payment system “C”) to 0.062 € 1 %⁻¹ (payment system “D”) for fat and protein content, respectively. The price corrections (+ / - in Table 2) were mostly linear and over the whole range of milk components content. The highest marginal importance of milk fat (253.05 € 1 %⁻¹) and proteins (461.71 € 1 %⁻¹) both expressed per cow and

Table 3: Marginal economic values (€ per unit of the trait per cow and year) of milk traits in pricing systems ¹

Trait (unit)	Pricing system							Median
	A	B	C	D	E	F	G	
Milk yield (kg)	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103
Milk fat percentage (%)	137.46	98.92	37.92	253.05	159.92	77.89	143.63	137.47
Milk protein percentage (%)	288.69	287.78	348.77	461.71	287.80	126.46	298.06	288.69
SCS (score)	-800.94	-14.71	-14.71	-541.51	-36.59	-551.00	-17.71	-36.59
Clinical mastitis (cases per cow and year)	-83.86	-83.86	-83.86	-83.86	-83.86	-83.86	-83.86	-83.86

¹ Detailed description of evaluated traits and pricing systems is given in Table 1 and 2 and in Material and Methods section.

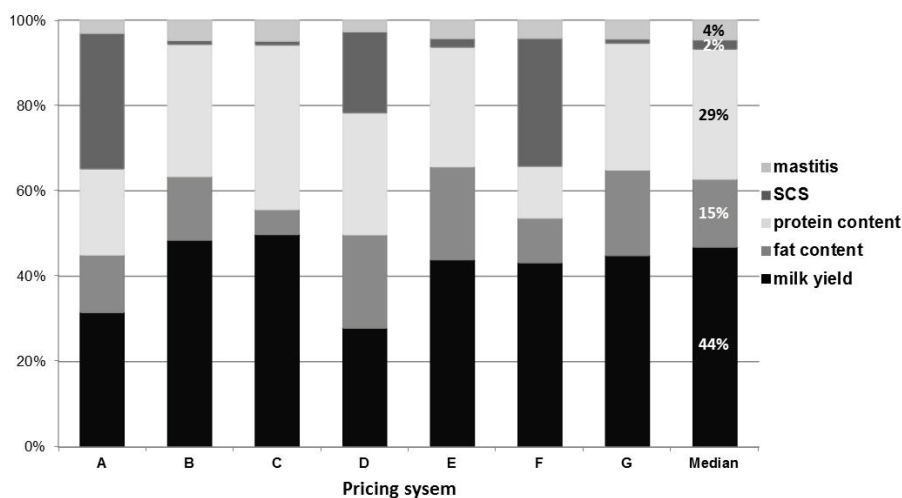


Figure 1: Relative economic values (%) of milk traits in pricing systems (Detailed description of evaluated traits and pricing systems is given in Table 2 and Material and Methods section.)

year was found in PS “D”. Contrary, the lowest economic values of milk components were calculated under the payment system “C” (37.92 € 1 %⁻¹ of fat) and “F” (37.92 € 1 %⁻¹ of protein). Similar variation in the marginal economic values of milk components under the various pricing systems was found by Wolfová *et al.* (2007). Relation of the marginal economic values for milk fat and protein content obtained in our study ranged from 1:9.2 to 1:1.62 which is comparable to those published for other European cattle breeds (from 1:2.2 to 1:3.7; Wolfová *et al.*, 2007; Komlósi *et al.*, 2010; Hietala *et al.*, 2016). Proportion favourable for milk protein content founded in our study in payment system “C” was based on the fact, that the upper threshold for milk fat content (3.5 %) was lying out from the Czech Holstein population average (3.8 %) and bonuses (0.014 € 1 %⁻¹ of fat) paid for additional increase of the trait mean would not be so profitable compared to bonuses for this trait in other payment systems (e.g. 0.029 € 1 %⁻¹ of fat). Therefore, next to the differences in pricing systems, also the trait definitions and its average population value were found as important factor for marginal economic value of milk traits in presented study and under the literature (Wolfová *et al.*, 2007; Hietala *et al.*, 2016).

Marginal economic importance for SCS was, similarly as for milk components, influenced by the variability in correction coefficients in individual payment systems. Penalties and bonuses oscillated there from -0.037 € per kg of non-standard milk (PE “B” and “C”) to 0.049 € per kg of Q-quality of milk (PA “A”). Based on the production system of Czech Holstein breed in 2015 the appropriate marginal economic values for SCS ranked from -14.71 to -800.94 € per score per cow and year in the payment system “B” and “C”, and “A”, respectively. It is

comparable with the literature resources (-241.05 € and -158.30 per score per cow and year; Komlósi *et al.*, 2010; Krupová *et al.*, 2016).

Marginal economic values for milk yield and clinical mastitis incidence remained without the change over the all pricing systems tested. It was due to the main aim of the study where impact of pricing system under the average economic (e.g. average milk price) and production (e.g. average milk yield of cows) conditions of Czech Holstein breed in the year 2015 was analysed. If the fluctuation of the milk price over the year (e.g. 0.258 € in August and 0.312 € in January per kg of milk in Czech Republic; MA CR, 2016) is considered the appropriate changes in marginal economic value of these traits are found. Similarly, as it was published by Wolfová *et al.* (2007) when individual purchased contracts for Holstein breed were modelled. Average milk price for Czech Holstein breed varied in this study from 0.238 to 0.290 € per kg of milk and marginal economic value from 0.101 to 0.163 € per kg of milk per cow and year. In our current study, a slightly lower economic value of milk yield (0.103 € per kg of milk per cow and year) compared to previous analyse was found in spite of the fact that average milk price over the years increased (0.276 € per kg in 2015) and milk subsidies (0.007 € per kg of milk) incorporated into the calculation in 2015 strengthened the economic importance of milk trait. We suppose that it can be associated to cost needed for additional milk production which increased much more intensive compared to additional revenues in the year 2015.

When deriving marginal economic importance of clinical mastitis incidence next to the depreciations, veterinary and farmers costs directly connected to mastitis incidence also the losses of discarded milk within

the clinical mastitis incidence were taking into account. Based on the main aim of the study, except of the payment system, all inputs of the bio-economic model for Czech Holstein breed remained constant. Therefore, average milk price and milk yield per lactation were as the main factors in our study. Total losses accounted for 83.86 € per clinical mastitis case per cow and per year for Czech Holstein cattle (9546 kg of milk per lactation and 0.276 € per kg of milk). For comparison, slightly lower economic losses (70.65 € per mastitis case per cow and year) calculated for local breed farmed in marginal areas was based on the lower milk yield (4473 kg per lactation) partially compensated with higher milk price (0.310 € per kg; Krupová *et al.*, 2016). Taking into account the negative relationship between clinical mastitis and milk yield in the rest of lactation and reproduction parameters the relative importance of this health trait (ranged from 3 to 5 % form economic importance all of the evaluated traits) could be increased considerably in the constructed selection index.

The next important result of this study is that economic values for milk and milk components were positive under all of the pricing systems. In another words, the additional costs related to the increase of individual traits by one unit (kg; %) was fully compensated by bonuses (defined in Table 2) and finally has positive effect on profitability of the production system. Negative economic value for fat content ($-30 \text{ € } 1 \text{ \%}^{-1}$ of fat per cow and year) was calculated in literature (Wolfová *et al.*, 2007) when only the penalties ($-0.107 \text{ € } 1 \text{ \%}^{-1}$ of fat) and no bonuses were applied in the given payment system. Moreover, it should be mentioned that relationship among evaluated traits has not been taken into account when their marginal and relative economic values were calculated to avoid double counting.

Genetic standard deviations were used to standardize the marginal economic values and to calculate the relative economic values of traits (Fig. 1). All inputs data were set on the production and economic conditions of Czech Holstein breed in 2015. However, actual genetic parameters of the evaluated traits have not been nowadays available. Therefore, approximation of genetic parameters of traits from the previous study (Wolfová *et al.*, 2007) was applied here. Due to this fact, relative proportion of the traits can be slightly influenced by such assumption. In spite of this fact, economic values of the traits were influenced by our assumption in the same way/direction and therefore, some general statement could be still made. Next to the milk yield (ranged from 28 to 50 %) also the milk components (from 6 % to 39 % for fat and protein content, respectively both in payment system “B”) remained as the most important milk traits.

To calculate the relative economic values of traits

and finally to provide the selection strategy in the population more precisely genetic parameters should be recalculated. The main reason is that population genetic and economic parameters substantially influence the constructed selection indexes (Šafus *et al.*, 2005). Moreover, application of index weights based on a ‘wrong’ pricing system as well as inappropriate genetic parameters of the population can reduce the total economic selection response in the future (Šafus *et al.*, 2005; Wolfová *et al.*, 2007). Optionally, taking into account the appropriate genetic parameters and the weights of traits makes possible to construct customised index according to economic conditions of individual herd (Příbyl *et al.*, 2004). Indeed for farmers it creates the room to consider the economic conditions (e.g. milk payment system) individually. Customized subindices for milk production traits would increase farmers’ profit from sire selection when selling milk on the basis of different pricing systems (Wolfová *et al.*, 2007). For example, next to the genetic predisposition of selected animal for milk yield also the protein content and SCS should be adequately considered in payment system “C” and “A”, respectively. The payment system “E” and “G” seems to be the most suitable when deriving economic values for the whole population due to the median of the marginal and relative economic values of the milk traits (Table 3, Fig. 1) and participation of these dairies on the overall dairy industry (7 % and 20 %, respectively) in the Czech Republic. Nevertheless, the actual marginal economic values can be fully implicated to define the economically important traits in Holstein cattle immediately the actual genetic parameters of traits are available.

4 CONCLUSIONS

Milk yield and milk components remained as the most important milk traits over all of the pricing systems analysed in our study. The pricing system confirmed as an important factor of economic values of milk traits creates the space to consider the economic conditions by individual farmer. This finding should be widely applied also in other breeds and production conditions. Marginal economic values of traits calculated in this study can be fully implicated for defining economically important traits in Holstein cattle immediately the actual genetic parameters of traits are available. Moreover, it should be mentioned that relationship among evaluated traits has not been taken into account when their economic values were calculated to avoid double counting. A further study therefore should be valuable to estimate responses in traits potentially included in the breeding goal for Holstein breed in the Czech Republic.

5 REFERENCES

- CMBC (2015). Results of Milk Recording in the Czech Republic. Control Year 2014–2015. Czech Moravian Breeders' Corporation, Inc., 129 pp. Retrieved from <http://www.cmsch.cz/store/rocenka-ku-za-rok-2014-2015.pdf>
- EC (*European commission*) (2015). Prospects for EU agricultural markets and income 2015–2025. EU Agricultural Outlook, December 2015, 84 p. Retrieved from http://ec.europa.eu/agriculture/events/2015-outlook-conference_en.htm
- Hietala, P., M. Wolfová, J. Wolf, J. Kantanen, J. Juga. (2014). Economic values of production and functional traits, including residual feed intake, in Finnish milk production. *Journal of Dairy Science*, 97, 1092–1106.
- Komlósi, I., M. Wolfová, J. Wolf, B. Farkas, Z. Szendrei, B. Béni. (2010). Economic weights of production and functional traits for Holstein-Friesian cattle in Hungary. *Journal of Animal Breeding and Genetics*, 127, 143–153.
- Krupová, Z., Krupa, E., Michaličková, M., Wolfová, M., Kasarda, R. (2016). Economic values for health and feed efficiency traits of dual-purpose cattle in marginal areas. *Journal of Dairy Science*, 99(1), 644–656.
- MA CR. (2016). Mléko – přehled roku 2015. Výsledky statistického zjišťování Mlék (MZe) 6–12. Měsíční výkaz o nákupu mléka, o výrobě a užití vybraných mlékárenských výrobků. Ministry of Agriculture of the Czech Republic. Retrieved from <http://eagri.cz/public/web/mze/ministerstvo-zemedelstvi/statistika/zemedelstvi/mleko/mleko-prosinec-2015.html>.
- Příbyl J., Šafus P., Štípková M., Stádník L., Čermák V. (2004). Selection index for bulls of Holstein cattle in the Czech Republic. *Czech Journal of Animal Science*, 49(6), 244–256.
- Šafus P., Štípková M., Stádník L., Příbyl J., Čermák V. (2005). Sub-indexes for bulls of Holstein breed in the Czech Republic. *Czech Journal of Animal Science*, 50(6), 254–265.
- Wolf, J., Wolfová, M., Krupa, E. (2013). *Users Manual for the program Package ECOWEIGHT (C Programs for Calculating Economic Weights in Livestock), Version 6.0.4. Part 1: Programs EWBC (Version 3.0.4) and EWDC (Version 2.2.3)*. Prague-Uhřetěves: Research Institute of Animal Production., 222 pp.
- Wolfová, M., Wolf, J., Příbyl, J. (2007). Impact of milk pricing system on the economic response to selection on milk components. *Journal of Animal Breeding and Genetics*, 124, 192–200.