Bulgarian Journal of Agricultural Science, 23 (No 2) 2017, 183–188
Agricultural Academy

ECONOMICS OF DUAL-PURPOSE DAIRY CATTLE UNDER VARIOUS MILK PRICING SYSTEMS

MONIKA MICHALIČKOVÁ*; ZUZANA KRUPOVÁ; EMIL KRUPA
Institute of Animal Science, Department of Genetics and Breeding of Farm Animals, 104 00 Prague 10, Czech Republic

Abstract

Michaličková, M., Z. Krupová and E. Krupa, 2017. Economics of dual-purpose dairy cattle under various milk pricing systems. *Bulg. J. Agric. Sci.*, 23 (2): 183–188

The impact of various pricing systems on the profitability of Slovak Simmental dairy cattle was evaluated using a bio-economic model. Pricing systems represented the most widespread variants of the contracts of farmers and dairies. Direct subsidies related to dairy herd were included when calculating the profit. The evaluated production system operated with loss per cow and year (455 €), which ranged from 326 to 589 € when delivering the same milk quality to various dairies. Orientation of dairy towards products with higher added value was found to be a comparative advantage. In contrast, high penalties for nonstandard milk resulting in a lower average milk price were competitive disadvantages. Moreover, the content of somatic cells was highly important in terms of the health security of milk production.

Key words: dairy cattle, bio-economic model, economics, pricing system

Introduction

Profitability of animal husbandry is strongly influenced by economics and by the biological specifics of production. A bio-economic model is a methodology that provides a comprehensive evaluation of biological (production and genetic variables) and economic aspects of the animal farm system (Wolf et al., 2013). In addition to economic and biological factors, supply chains (including also the pricing system) generally play an important role in the economics of dairy production (Kahi and Nitter, 2004). In Slovakia, the pricing system (milk price) in most dairies is based on milk volume and standards for fat and protein contents, below or above which bonuses or penalties are added to or subtracted from the base milk price. As you will see in the next parts of paper, the milk pricing system varies largely among farms and dairies ("Material and Methods" section).

In the last ten years, the milk sector has undergone two large changes. After 2009, the average milk price dropped, and overall costs per cows increased (due to higher prices of inputs). Furthermore, the abolition of milk quotas in 2015 has created stronger pressure on milk production throughout Europe. Currently, the profitability of dairy farms is more dependent on the diversification of production. Considering the current unstable economic situation in animal production, dual-purpose breeds are useful for reducing the risk of dairy farms. At present, the Slovak Simmental cattle, the most prevalent dual-purpose cattle, amounts to 163 721 animals produced/milked, with 5717 kg of milk per 305 d lactation on average (4% fat and 3.4% protein content in kg of milk).

The aim of this study was to provide a comprehensive evaluation of the influence of various pricing systems (described in "Material and Methods" section in details) on the profitability of the dairy farm system of Slovak Simmental cattle using a bio-economic model. To the authors' best knowledge, this type of interdisciplinary analysis (based on real dairy contracts and using a bio-economic model) will be the first applied to local conditions.

*Corresponding author: moni.michalickova@gmail.com

Materials and Methods

Pricing systems

In all of the evaluated dairies, the base milk price was paid per kg of milk according to fat and protein content and the proportion of milk over the individual quality classes of the somatic cell count (SCC). However, individual threshold value/s and price corrections (bonuses and reductions) for the milk components (fat and protein content) and for SCC varied among the evaluated pricing systems. Therefore, the average milk price remained not constant over pricing systems. For example, the pricing system B was primarily focused on products with higher added value, which is reflected in the higher basic milk price and bonuses paid per milk components. The systems representing the most widespread variants of pricing systems in Slovak dairy farms were gradually applied to the bio-economic model while other inputs for Slovak Simmental breed remained constant. Direct impact of given pricing system to the economic result per cow and year was quantified. A detailed description of the evaluated pricing systems with specification of penalties and bonuses (A-C) is given in Table 1.

Farm System

Current level of production and economic data for dairy population of the Slovak Simmental cattle was applied in the study. The farm system was treated as self-reproducing, with the rearing of breeding animals for their own replacement. A classical indoor farming system with the export of surplus male progeny and selling of surplus pregnant breeding heifers was assumed as a marketing strategy. The main economic and production inputs of dairy population were carried out using data from a total of 12 cattle farms (2723 cows; basic production and economic evidence of farms) in Slovakia during the period 2011 to 2013 (methodology described e. g. in Michaličková et al., 2014). Production data were obtained also from previous studies dealing with the local dairy cattle population (Krupa et al., 2005; Krupová et al., 2016) and from performance testing provided by the Breeding Services of the Slovak Republic. The trait mean values and genetic standard deviations are described in details in Table 2. The stationary state of the herd structure was derived using the Markov chain procedure (Wolfová et al., 2007).

Table 1
Input parameters for calculating revenue from milk and description of pricing systems

Variable (unit)	Pricing system		
	A[1]	B[2]	C[3]
Basic milk price (€ cents per kg)	28.07	31.00	26.48
Bonus for milk protein percentage (€ cents per % of protein)	0.8	1.2	0.9
Bonus for milk fat percentage (€ cents per % of fat)	0.7	1.0	0.6
Price reduction for nonstandard milk (€ cents per kg of milk)	4.6	6.3	11.7
Average milk price (€ cents per kg of milk)[4]	29.40	31.80	26.70

[1]The basic milk price – SCC ≤ 400,000 cells per mL, and the fat and protein contents ≤ 3.6 and 3.2 %, respectively. Reduction for milk with SCC ≤ 400 000 cells per mL and for fat and for protein content ≤ 3.6% and 3.2%, respectively. [2]Basic milk price – SCC ranges from 300 000 to 400 000 cells per mL, and fat and protein contents range from 4.2 to 3.1 % and from 3.6 to 2.8 %, respectively. Reduction for milk with SCC ≤ 400,000 cells per mL and for fat and for protein content ≤ 3.1 % and 2.8 %, respectively. [3]Basic milk price – SCC ≤ 400 000 cells per mL and fat and protein content range from 3.6 to 3.8 % and ≤ 2.8 %, respectively. Reduction for milk with SCC ≤ 400 000 cells per mL and for fat and for protein contents ≤ 3.3 % and 2.8 %, respectively. [4]Price per kg of milk of given fat (4 %) and protein (3.4 %) contents and given somatic cell count (472 300 cells per mL) in the population

Table 2
Means and genetic standard deviations (GSD) for basic characteristics of Slovak Simmental population

Trait (unit)	Mean	GSD
Milk yield (kg per cow and lactation)	5717	368
Fat content (%)	4	0.21
Protein content (%)	3.4	0.09
SCS[1] (score)	4.72	0.085
Calving performance (score)	1.26	0.05
Losses of calves at calving[2] (%)	8.3	3.1
Losses of calves till weaning[3] (%)	6.8	1
Conception rate of cows (%)	91	1.5
Conception rate of heifers (%)	93	1.5
Productive lifetime of cows (years)	3.14	0.3

Source: Krupa et al. (2005), Krupová et al. (2009)

[1]Somatic cell score calculated as $\log_2$ (SCC/100,000)+3. [2]Losses of calves at calving include aborts, calves born dead, and calves that died within 48 h after calving.[3]Losses of calves to weaning expressed as proportion of calves born alive

Profit function

Profit was the criterion of economic efficiency for the modelled farm system (Wolf et al., 2013):

$$profit = rev' \times NDE^{(rev)} - cost' \times NDE^{(cost)}, \quad (1)$$

where ***rev′*** and ***cost′*** are the row vectors of revenue and costs per animal, respectively, the elements of which are rev_i and $cost_i$, with i being the category of animals. $\boldsymbol{NDE^{(rev)}}$ and $\boldsymbol{NDE^{(cost)}}$ are the column vectors of the number of discounted expressions connected with revenues and costs, respectively, the element of which are $NDE_i^{(rev)}$ and $NDE_i^{(cost)}$. All revenues and costs occurring in the herd during a year and in the life of progeny born in the herd were discounted to the date of birth of the progeny. An annual discount rate of 1.0 % (estimated as the difference between the average annual investment rate and inflation rate in Slovakia during the evaluated period) was used.

Revenues were calculated from milk, breeding heifers, slaughtered cows and manure. Revenue from milk was a function of quantity, fat and protein content and SCC. To calculate these values, the pricing system, the basic price, the milk yield and proportion of cows on individual reproduction cycles, the calving interval, the length of the lactation period and the modified Wood production function (Fox et al., 1990) were taken into consideration in the bio-economic model. Revenues from slaughtered animals were a function of the live weight at slaughter, the dressing percentage and the average price per kg of carcass weight, defined on the basis of the distribution of carcasses across fleshiness and fat-covering classes within the SEUROP grading system (Table 3). Moreover, direct subsidies paid in relation to dairy herd were included in the revenues. The average value of individual subsidy payments for the period of 2011 to 2013 was used (Krupová et al., 2016). The input parameters for the calculation of revenues are listed in Table 3.

Table 3
Input parameters for calculating other revenues

Variable (unit)	Value
Average price by weight (€ per kg of live weight)	
Calves[1]	2.4
Heifers[1]	1.3
Cows[2]	1.2
Average live weight (kg per animal)	
Calves	116
Heifers	515
Cows	597
Price for manure (€ per 100 kg)	0.03
Production of manure per cow (kg per d)	45
Direct subsidies[3]	
Milk production (€ per kg of milk)	0.0117
Livestock unit (€ per cow and year)	88.06
Performance testing (€ per cow and year)	23.13

[1]Price is given per kilogram of live weight of female and male calves upon weaning at age 100 d and per kilogram of live weight of heifers sold pregnant at 900 d of age. [2]Price is given per kilogram of live weight for culled cows. [3]Average value of direct subsidies during 2011 to 2013. Subsidies for performance testing included subsidies for all cattle categories in the herd (calves to 6 mo, cattle from 6 to 24 mo, and bulls and heifers up to 24 mo taken as 0.2, 0.6, and 1.0 livestock units, respectively)

Costs were calculated separately for feeding, housing, breeding and health. All other costs were accounted for as a fixed cost per animal category per day (Table 4). Housing costs were those for bedding, i.e., costs for straw minus revenues for manure. Breeding cost were those associated with artificial insemination and included the price of semen, labour and services per conception. Health costs included veterinary costs per animal, dystocia cost per calving and the cost of removing and rendering dead animals (Wolfová et al., 2007).

Table 4
Input parameters for calculating health, other and fixed costs

Variable (unit)	Value
Price of semen for artificial insemination (€ per insemination dose)	8
Average number of inseminations per heifer/cow	5/6
Number of reinseminations	1
Costs for veterinary care[1] per cows (€ per animal and reproductive cycle)	85
Costs for dystocia[2] – calving score 3/calving score 4 (€ per calving)	39.7/79.9
Costs for water (€ per d)	0.1
Cost for straw for bedding for cows (€ per d)	0.06
Fixed costs[3] (€ per animal and d)	
Cows	2.8
Reared calves	0.81
Breeding heifers	1.14

[1]Included are costs for veterinary fees, drugs, dystocia, mastitis and claw disease. [2]Four score are used for calving performance: easy calving without help (1), easy calving with help (2), difficult calving with veterinary assistance (3), calving with caesarean section (4). [3]Included are costs for labour, energy, fuels, repairs, insurance, interest on investments and overhead costs

The bio-economic model of the program EWDC (version 3.0.4) from the ECOWEIGHT 6.0.4 program package (Wolf et al., 2013) was used for all calculations.

Results and Discussion

Revenues and costs

Generally, variation in farm milk prices (Table 1) has significant effects on dairy farm revenues (Nicholson and Stephenson, 2015). In our study, over the evaluated pricing systems, revenues from milk were found as the most important item (85% on average without subsidies including) of the revenues of the dairy Slovak Simmental population. This finding is consistent with the papers of Vargas et al. (2002), Krupová et al. (2009) and Kahi and Nitter (2004) where the milk accounted for 83 to 95% of total incomes. In the last cited paper, proportion of milk was found similar in spite of the fact that the payment for milk was based on the volume of milk and do not considered its composition. As these authors stated (Kahi and Nitter, 2004), milk fat content should not be omitted as a trait in the breeding objective even in the case when milk components are not paid because of impact on the feed costs. Moreover, milk production traits have traditionally received a large emphasis in the national breeding programs of dairy and dual-purpose cattle in many countries e. g. (Wolfová et al., 2007; Komlósi et al., 2010; Hietala et al., 2014). Proportion of milk revenues dropped in our study to 78% (Figure 1) when considering the direct subsidies; however these were omitted from calculation in above cited papers. Taking into account the evaluated Slovak population, the second most important part of revenue was that for sold surplus calves, breeding pregnant heifers and for manure (9%). This finding is consistent with Kahi and Nitter(2004) as well as with the general goal of this breed, i.e. to farm a productive dual-purpose (milk and meat; 60:40) cattle.

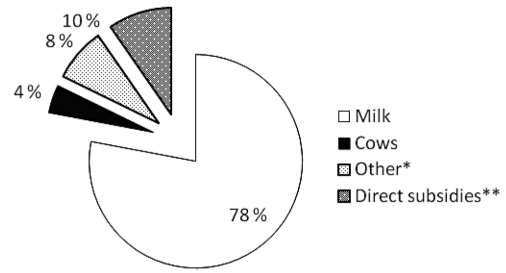

Fig. 1. Average structure of revenues in dairy farms of Slovak Simmental

* Revenues calculated from sold breeding heifers and manure. ** Average value of direct subsidies during 2011 to 2013. Subsidies for performance testing included those for all cattle categories in the herd (calves to 6 mo, cattle from 6 to 24 mo, and bulls and heifers up to 24 mo taken as 0.2, 0.6, and 1.0 livestock units, respectively)

As expected, total costs per cow and year remained constant over the evaluated farm system. Based on the current production and economic situation, the fixed costs (54%) and feeding costs (38%) were found to be the most important cost items of the overall profitability (Figure 2). In most of the studies presenting the economic results of dairy farms e. g. (Wolfová et al., 2007; Hietala et al., 2014), the price of pastures and meadows used for grazing of cattle is included in the feed costs along with the farm's own and purchased feeds and litters. In the bio-economic model applied here and also in other studies (Hietala et al., 2014; Krupová et al., 2016), feeding costs were calculated on the basis of daily energy and protein requirements for maintenance, growth, milk production, pregnancy and the activity of individual animal categories and according to the average price per kilogram of fresh matter in feeding rations with dry matter, net energy and protein contents. This approach was preferred by Kuipers (1999) because it is important to utilize production potential in relation to the given output level, i.e., the milk yield. Contrary to our results, e g., Kahi and Nitter (2004) observed the prevalence of variable costs in the calculation (98%). This finding is related with the extensive low-input farm system of dairy cattle, as well as with the different categorization of individual cost items.

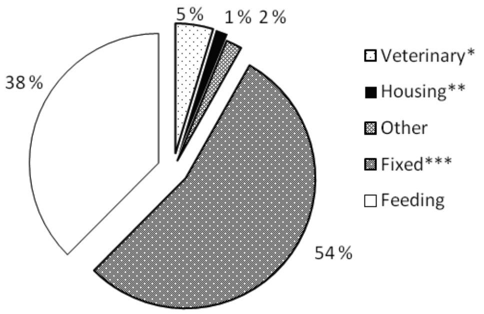

Fig. 2. Average structure of costs in dairy Slovak Simmental farms

*Includes costs for clinical mastitis incidences and other veterinary treatment (e.g., dystocia cost expressed per calving and cost for removing and rendering dead animals). **Includes bedding, i.e., costs for straw minus revenue for manure. ***Includes costs for labour, energy, reparations, insurance, fuel, overhead and depreciation of property

Economics of cattle

Considering the actual production and economic conditions, the farming of Slovak Simmental dairy cattle operates with loss of 455 € per cow and year on average (include also the subsidies and revenues from milk and other categories of sold animals). The negative economic results ranged from 326 to 589 € when delivering the same milk quality to various dairies (i.e., according to various pricing systems, Figure 3).

Higher variability in the profit value (+63.8 to -792 € per cow and year) published by Chrastinová et al. (2011) was mainly due to differences in production and economic indicators in the analysed herds. For example, the milk yield varied from 2.7 kg to 6.1 kg per feeding day, and costs ranged from 24 to 749 € per cow and year. In contrast, Wolfová et al. (2007) observed much positive economic result for Czech Fleckvieh cattle varying from -103.8 to 174.6 € per cow and year (without including subsidies). In spite of the comparable production parameters between the Slovak and Czech dairy population, lower penalties for milk fat and milk protein content (-0.3 € cents and -0.1 € cents per %

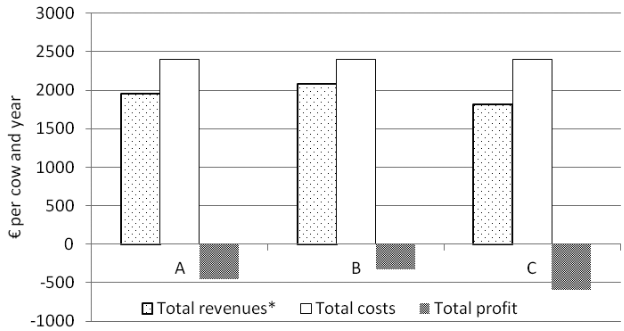

Fig. 3. Economic result of farm based on the evaluated pricing systems

* Revenues calculated from milk, breeding heifers, slaughtered cows and sold manure

of fat and protein content in kg of milk, respectively) were paid according to the payment system applied in their study. Moreover, the reduction of milk price for nonstandard milk was not as strictly compared to our study (6.5 vs. 7.5 € cents per kg of milk), and bonuses for the amount of milk delivered from each farm to dairies were taken into consideration in their study. In accordance with our results, Vargas et al. (2002) stated that the economic results of a dairy farm are strongly dependent on the pricing system and breed and are independent of quota. The abolition of milk quotas in 2015 has played a minimal role in our study as well because the quota has not been filled (85% on average) in the Slovak conditions; therefore, they were not incorporated into the calculation.

The ratio of the minimum to the maximum economic results over evaluated pricing systems was 81% (-589 € and -326 € per cow and year for C and B pricing systems, respectively). This ratio is related with the average parameters of evaluated Slovak Simmental population where the fat, protein and SCC content reached 4%, 3.4% and 472 300 cells per mL, respectively.

Based on the population characteristics, the average value of protein content in kg of milk was already in the bonus payment area for all pricing systems. Moreover, the same was true for the fat content in pricing systems B and C. The comparative advantage of the farm producing under the pricing system B was based on a characteristic of the given dairy factory. It is primarily focused on products with higher added value (e.g., cheese, cottage cheese and acidophilic products), which is reflected in the higher basic milk price and bonuses paid per milk components. Therefore, farmers selling milk to such dairies have a motivation to improve the milk yield per cow as well as the content of milk components. One way to provide this is through the overall farming conditions (i.e., welfare) and also through the breeding process. In contrast, the highest loss per cow and year calculated for farms selling the milk with pricing system C was based on two large competitive disadvantages. Basic milk price was lower and penalties for nonstandard milk were higher in comparison with the rest of analysed payment systems. It is important to mention that SCC is frequently used to determine quality payments to dairy producers (Bujko et al., 2014). Generally, the European Union requires that milk used for dairy products sold in its territory must have SCC under the 400 000 cells per mL. Based on this fact the SCC is checked daily by farmer during milking period and this trait is also included in the breeding goals and selection schemes of many dairy cattle breeds (Zavadilová et al., 2011). Altogether, SCC is used to the monitor the health status (mastitis incidence) of the herd (Kahi and Nitter, 2004; Zavadilová et al., 2011). Finally, it can be stated that the profitability of dairy farms was very sensitive to the payment system before the milk crisis in 2009 (Vargas et al., 2002), and this remains true. Likewise, as reported Wolfová et al. (2007), the importance of fat and protein content, as well as udder health traits is higher when greater emphasis on milk components and the strict definition of qualitative parameter in the milk pricing system is applied.

The results of this study fully confirmed that the milk pricing system in addition to production conditions is one of the key parameters determining the profitability and thus sustainability of dairy farms. From farmers' point of view, one option to improve milk prices is to focus on the milk components for which adequate bonuses are paid. However, orientation of farmers towards the higher milk and protein content should be strongly individual depending on motivation from dairies as well farm production and economic conditions. The variability of the evaluated milk pricing system can also influence the motivation of farmers to improve the milk yield per cow and/or the content of milk components and the milk quality. There are many solutions to provide improvements, e.g., through farm management organization, motivation system and utilisation of resources (i.e., welfare), the breeding process not excluding. Moreover, somatic cells content is highly important in the health security of milk production. Results founded in this study provide pilot information to revaluate the breeding goals for the local dairy cattle population in the near future.

Acknowledgements

The authors would like to thank dairy cattle farmers for providing production and economic data, as well as to Jozef Bujko, from The Slovak University of Agriculture in Nitra for his helpful comments and English Language Editing for editing the text. This study was funded by the project QJ1510217.

References

Bujko, J., J. Candrák, J. Žitný and C. Hrnčár, 2014. Factors affecting on somatic cells count in Slovak Simmental Dairy Cows. *Scientific Papers: Animal Science and Biotechnologies*, **47**: 32-36.

Chrastinová, Z., V. Burianová and A. Trubačová, 2011. Evaluation of agricultural production economic effectiveness according to legal forms of farming. *Economics of Agriculture*, **11**: 2-13.

Fox, D. G., C. J. Sniffen, J. D. O'Connor, J. B. Russell and P. J. Van Soest, 1990. A model for predicting cattle requirements and feedstuff utilization.In: The Cornell Net Carbohydrate and Protein System for Evaluation of Cattle Diets. Cornell Univ. Agr. Exp. Sta. No. 34. *Cornell University*, Ithaca, NY, pp. 7-84.

Hietala, P., M. Wolfová, J. Wolf, J. Kantanen and 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.

Kahi, A. K. and G. Nitter, 2004. Developing breeding schemes for pasture based dairy production systems in Kenya. I. Derivation of economic values using profit functions. *Livestock Production Science*, **88:** 161-177.

Komlósi, I., M. Wolfová, J. Wolf, B. Farkas, Z. Szendrei and B. Béri, 2010. Economic weights of production and functional traits for Holstein-Friesian cattle in Hungary. *Journal of Animal Breeding and Genetics*, **127**: 143-153.

Krupa, E., M. Wolfová, D. Peškovičová, J. Huba and Z. Krupová, 2005. Economic values of traits for Slovakian Pied cattle under different marketing strategies. *Czech Journal of Animal Science*, **50**: 483-492.

Krupová, Z., J. Huba, J. Daňo, E. Krupa, M. Oravcová and D. Peškovičová, 2009. Economic weights of production and functional traits in dairy cattle under a direct subsidy regime. *Czech Journal of Animal Science*, **54**: 249-259.

Krupová, Z., E. Krupa, M. Michaličková, M. Wolfová and R. Kasarda, 2016. Economic values for health and feed efficiency traits of dual-purpose cattle in marginal areas. *Journal of Dairy Science*, **99**: 644-656.

Kuipers, A., F. Mandersloot and R. L. G. Zom, 1999. An approach to nutrient management on dairy farms. *Journal of Animal Science*, **77**: 84-89.

Michaličková, M., Z. Krupová, P. Polák, L. Hetényi and E. Krupa, 2014. Development of competitiveness and its determinants in Slovak dairy farms. *Agricultural Economics – Czech*, **60:** 82-88.

Nicholson, C. H. F and M. W. Stephenson, 2015. Milk price cycles in the U.S. dairy supply chain and their management implications. *Agribusiness*, **31**: 507-520.

Vargas, B., F. Groen, M. Herrero and J. A. M. Van Arendonk, 2002. Economic values for production and functional traits in Holstein cattle of Costa Rica. *Livestock Production Science*, **75**: 101-116.

Wolf, J., M. Wolfová and E. Krupa, 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). *Research Institute of Animal Production*. Prague-Uhříněves. 222 pp.

Wolfová, M., J. Wolf, J. Kvapilík and J. Kica, 2007. Selection for profit in cattle: I: Economic weights for purebred dairy cattle in the Czech Republic. *Journal of Dairy Science*, **90**: 2442-2445.

Zavadilová, L., J. Wolf, M. Štipková, E. Němcová and J. Jamrozik, 2011.Genetic parameters for somatic cell score in the first three lactations of Czech Holstein and Fleckvieh breeds using a random regression model. *Czech Journal of Animal Science*, **56**: 251-260.

Received October, 13, 2016; accepted for printing March, 10, 2017