KVANTITATIVNÍ MĚŘENÍ NEGATIVNÍCH TECHNOLOGICKÝCH ZMĚN V KVALITĚ PRODUKCE SYROVÉHO MLÉKA

TECHNOLOGY-RELATED QUANTITATIVE MEASUREMENT OF QUALITATIVE RISKS IN RAW MILK PRODUCTION

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Abstrakt:
Produkce mléka vynikající kvality je v zemědělství předpokladem konkurenceschopnosti a prodejnosti. V našem výzkumu jsme na základě technologií používaných na mléčných farmách vyvinuli model kvantitativního vyhodnocování rizika pomocí logistické regresní analýzy. Tento model udává pro každou farmu skóre od nuly do sta a zároveň pro jednotlivé farmy stanovuje optimální produkční podmínky potřebné pro nejvyšší možnou kvalitu mléka za nejvýhodnější ceny.

Klíčová slova:
risk analýza, produkce mléka, logistická regrese, optimální produkce, dojící zařízení, skladovací plochy

Abstract:
The production of excellent quality milk is a precondition for agricultural competitiveness and marketability. In our study, we developed a model of quantitative risk scoring through a logistic regression analysis of the technologies used on dairy farms. The model gives scores ranging from 0-100 to each farm, and determines the optimal production conditions needed for a given farm to produce the highest quality milk at the best possible price.

Key words:
risk analysis, milk production, logistic regression, optimal production, milking equipment, storage warehouses

INTRODUCTION

Agricultural production is comprised of highly risky activities, since yields cannot be pre-calculated by decision making procedures. Several authors have discussed the sources and significance of agricultural risks (Hazell and Norton, 1986; Hardaker et al., 1997; Rimovská, 2002). According to the literature, prospective results are affected by several factors which result in uncertainties and risks in production. Nábrádi and Jávor (1999) claim that better quality breeding animals, higher level foraging and care are indispensable for the production of quality products, irrespective of species and related products. Under market economic circumstances, only those farms are capable of surviving which constantly offer high quality products. Husti (2003) states that quality improvement is one of the key areas requiring development in the agricultural sector. This is true of dairy farms, as well. As this sector requires considerable fixed assets, the withdrawal of capital in Hungary following the change of regime has been hampering the activities of agricultural production (Szűcs, 2005). Ráki (2004) and Dienesné (1996) discuss the problems associated with low financial input in their farm studies, referring to the poor technical condition of buildings and equipment, which hinder high level quality production in numerous dairy farms. Available resources should be

effectively used for farm modernization, as these can improve raw milk quality (Bodnár and Horváth (2005).
Fortunately, the rate of extra quality raw milk has increased significantly (approximately by 20%) in recent years (Szabó and Popovics, 2002). About 90% of the raw-milk produced in Hungary is of extra quality (Popovics, 2005). As the hygienic quality of raw milk is affected by udder health (24%) and milking (25%) (Nagy and Felföldi, 1999), studies focusing on this area are of key importance. Milk quality is closely related to its selling price; therefore, milk farms should strive to attain higher quality and further enhance the rate of their extra quality milk.
Due to all the factors discussed above, we decided to study the technological conditions of milking on selected dairy farms in Hajdú-Bihar County, focusing on the types of milking machines, milking time per milker and the number of milking units per milker, as well as on udder-cleaning methods and storage warehouses. Our analyses are based on the development of risk scores using the method of logistic regression, which is also used in debtor qualification in the business sector. Our purpose was to examine and evaluate the work processes and, therefore, the technological conditions affecting quality milk production in milking houses, and to use these findings for efficiency improvement and more profitable production on dairy farms.

OBJECTIVES AND METHODS

The data for our analyses were supplied by the Laboratory for Raw Milk Qualification, Experimental Institute of Hungarian Milk Farming in the period of 2000-2005, through 162 ten-day cycles.
The study included 35 dairy farms in Hajdú-Bihar County. On the basis of data from 2004/2005, there are 68 large dairy farms in Hajdú-Bihar County, on which are kept 80% of the total number of cows in the county. Therefore, the study of milk quality covered about 50% of the total dairy farms in the county.
These farms were selected to represent each type of farm, from those with only approx. 50 cows, to big farms with up to 1,100 cows. We examined the applied technologies (udder-cleaning method, type of milking machine, method of forage storing, time of milking, number of used milking machines, the use of automatic leat cup removers) by Szendrő-Szíjjártó's (1979) method. In the investigated dairy farms mobile (carrousel) and immobile (herringbone, polygon, index) devices were used, whereas 60% of dairy farms used herringbone milking machines. This proves the opinion by Stefler et al. (1995) and Báder (2002) that this milking system is the most frequently used such technology on farms for free range animals. The type of milking machines and other technological factors are decisive in quality milk production. Using logistical regression, we developed a model which calculated the risk indicators for milk quality on the basis of farm characteristics and evaluated technological elements according to the risks they posed.
In a logistical regression model, the logarithm of the odds for event occurrence is estimated (rate of odds for favourable and unfavourable occurrence) in relation to explanatory variables (risk factors). Logarithmic transformation is used since we strive for retaining the estimated odds in the (0.1) range, so that the edges of the interval should not increase or decrease fast. The use of logistical regression for developing risk factors can be found in the literature (Hand, 2001; Parr, 2001). This method is mostly used in debtor qualification, e.g. we can predict if debtors in certain age categories, with given incomes, family status and office rank are likely to pay or not. In the case of dairy farms, we would like to predict if milk quality is excellent in a given ten-day cycle or not. The 1 value of Y, the two-category dependent variable in the model means non-extra quality; its 0 value means extra quality milk. On the

basis of the logarithm of odds for producing non-extra quality milk we developed score values, as follows:

$$\ln\left(\frac{p[Y=1|x]}{p[Y=0|x]}\right)=\beta_0+\sum_j \beta_j \cdot x_j$$

$$score = a + b \cdot \ln\left(\frac{p[Y=1|x]}{p[Y=0|x]}\right)$$

$$p(non-extra)=0.5 \rightarrow score = 100 = a$$
$$p(non-extra)=0.001 \rightarrow score = 0 = c \quad \Rightarrow \quad b=\frac{c-a}{\ln\left(0.001/1-0.001\right)}=\frac{-100}{\ln\left(1/999\right)}$$

In the most extreme case, the rate of extra milk is 50% as compared to that of non-extra milk, and the given farm is given 100 risk scores according to parameter "a". In the most favourable case, extra milk is produced in 99% in a dairy farm, this time the risk index is 0. The higher the rate of non-extra quality milk production, the better the index value approximates 100. If the risk of quality deterioration falls back with 50%, the index value decreases by 10. First the method estimates the logarithm of odds on the basis of primary data, and then it calculates the probability of non-extra milk production according to the formula used below:

$$P(Y=1)=\frac{e^{B_0+B_1X_1+....B_kX_k}}{1+e^{B_0+B_1X_1+....B_kX_k}}$$

This method ranks those farms into the non-extra quality category in the given ten-day cycle, in which this probability exceeds a preliminarily given critical cut value. As the rates dominantly shift in favour of extra quality, we decreased the critical cut value from the usual value of 0.5 to 0.15, so the model has evaluated the quality of farm milk with the precision of 82.9%.

RESULTS AND DISCUSSION

The parameter evaluation of the logistical regression model fitted on the explanatory variables included in the analysis and on 10 day-cycles of 4.5 years are presented in Table 1. The variables can be categorical and of scale types as well. In the case of categorical variables, the last category is the so-called reference category, and the other values are plotted against this in relation to risk. The negative β parameter of the given factor means that the factor decreases the odds for the farm to produce non-extra quality milk. The factor of positive parameter increases the odds of non-extra quality milk. The $\exp(\beta)$ relative risk indicator shows the variations in odds. The quotient of two probabilities is called odds. For example, for milk quality it means that the probability of extra quality production is divided by the probability of non-extra quality production, thus we get the odds for extra quality milk production.

Significance levels show that almost each variable exerts significant effects. Table 1 presents that the fewer milking machines a milker uses, the lower the risk of quality deterioration is. Optimally, a milker is totally occupied with not more than 8 milking machines. However, the risk parameter is unusually low when a milker uses 16 machines, because the data from carrousels with 16 stands are also included here, which greatly improved the parameter value.

The comparison of milking machines shows that as compared to herringbone milking machines, carrousels are less risky and more up-to-date in terms of quality, followed immediately by polygons. In those farms, where automatic leat cup removers are not used, the odds of quality deterioration are 1.5 times greater than compared with farms using automatic teat cup removers. Forages should be stored in silage warehouses, whereas mass feeding stuff should be stored in farm-yards, in contrast with other solutions. In udder cleaning, traditional methods (water hose, towel with disinfectant, paper towel) proved to be the most effective in terms of milk quality. If the production of 100 l milk takes more than 1 hour, the odds for quality deterioration grow 1.6 times higher.

Table 1 – Results of parameter estimation by logistical regression model**

Variables	B parameter	Significance (p value)	Exp(B) Relative risk
10 day cycle	-,037	,000	,964
Number of milking machine		,000	
4	-2,841	,011	,058
5	-2,867	,000	,057
8	-2,307	,003	,100
10	-1,003	,161	,367
11	-1,506	,010	,222
12	-1,593	,001	,203
14	-,796	,342	,451
16	-1,846	,003	,158
18*	0		1,000
Milking machine		,031	
Carrousel	-1,685	,033	,185
Polygon	-,296	,499	,744
Index	-,424	,129	,655
*Herringbone**	0		1,000
Number of milk refrigerators		,548	
1	-,361	,352	,697
2	-,047	,882	,954
*3**	0		1,000
Automatic teat cup remover (no)	,371	,061	1,450
*Yes**	0		1
Fodders stored in buildings	,532	,034	1,702
Silage warehouse *	0		1,000
Mass feeding stuff		,002	
Farm yard	-3,216	,001	,040
Silage warehouse + farm yard	-1,028	,084	,358
Silage warehouse + building *	0		1,000
Udder cleaning		,000	
water hose + paper towel	-,732	,046	,481
water hose + cloths	-,408	,492	,665
towel with disinfectant	-1,235	,020	,291
dipping teats + paper towel	-,764	,055	,466
towel with disinfectant	-1,821	,001	,162
water hose	-3,457	,002	,032
dipping teats + cloth*	0		1,000
Man hour for producing 100 l of milk	,478	,003	1,613
Number of cows for 1 physical worker	-,004	,849	,996
Constant	,288	,828	1,334

Source: author's estimation;

* reference category; ** the model Chi-square test was significant (Chi^2=289,179; df=26; p =0,00)

CONCLUSIONS

The model provides insight into the development of optimal production conditions, since it is suitable for predicting the odds of production quality in farms related to the given values of decision-making variables, i.e. it is capable of risk assessment. Risks are the lowest when carrousels are used in milking, mass feeding stuff is stored in farm-yards, forages in silage warehouses and optimally one milker is occupied with 8 milking machines. In udder cleaning traditional solutions (water hose, towel with disinfectant) are effective in contrast with other ones for milk quality; without using automatic teat-cup removers, the odds of milk quality deterioration are 1.5 times greater. It is significant to produce 100 l of milk in fewer man hours, since each extra man hour increases the odds of milk quality deterioration 1.6 times greater. As regards the methods of risk and economical assessment, we regard it essential to emphasise that due to the puzzling nature of the dependence of effects upon causes, in the case of any kind of method or calculation, clear correlations and effects can always and necessarily be only approximated and reflected.

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