ASSESSMENT OF KEY ASPECTS OF TECHNOLOGIES AND COW FARMING FOR MILK PRODUCTION IN LATVIA

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Abstract. In Latvia, the dairy industry was ranked second with 24.1 % in the distribution of agricultural final products in 2014, and more than a third of all commercial agricultural farms were linked to this industry. A combination of the abolishment of the EU milk quota system and the Russian embargo created challenges, which had a significant impact on the agricultural sector. Therefore, it is important to examine various problems related to cow farming and farm technologies, as they are essential for competitive milk production from every cow. It has been found that the key standard solutions, which determine the successful performance of dairy farms, are cow breeds and their potential, conditions and technologies for cow farming, cow diets and cow milking. An examination of 74 dairy farms of various sizes in the entire territory of Latvia revealed that the highest performance results (the highest milk yields per cow) were observed for large farms that kept cows unstanchioned in their cowsheds (the loose-housing system) with no grazing period, and mostly two technologies were used in milking the cows: the herringbone milking system and the carousel milking system. Milking three times a day was practised mostly by farms using the carousel milking system, thus achieving higher milk yields per cow.

Keywords: technologies, cow farming, milk production, indicators.

Introduction

According to Murray C. [1], the demand for dairy products is expected to grow over the medium term, largely reflecting population growth, rising incomes and further westernization of diets, particularly in Asia, the Middle East and North Africa. This growth in demand is expected to provide support to world dairy prices over the next few years. Other scientists have similar opinions, pointing out that milk production in the major dairy exporting countries is expected to rise in 2015-2016 as milk yields will increase, feed costs will remain low and the EU milk quota system will be removed [2]. The Russian embargo, introduced in August 2014 for selected agricultural imports from the most of the western world, led to imports of dairy products being sourced from alternate suppliers. Low world prices for dairy products have resulted in increased demand for milk powder imports from several ASEAN countries, including Indonesia, the Philippines, Thailand and Malaysia [3].

Milk production is the second most important agricultural sector in Latvia with 24.1 % in the distribution of agricultural final products in 2014 [4]. That is why it is important that under the conditions when, on the one hand, the global demand for dairy products rises, while, on the other hand, there is a complicated situation in the European market related to abolishment of milk quotas and Russia's imposed embargo, the dairy industry develops in Latvia, as it provides jobs and stabilises the economies of rural territories.

Therefore, the overall objective of this research is to identify the key standard technologies and solutions in milk production in order to determine their effects on milk yield. To achieve that, the following specific research tasks are defined: 1) to identify the key standard technologies and solutions in farming cows on dairy farms in Latvia; 2) to assess the effects of technologies and cow farming aspects on milk yield.

Materials and methods

Materials used for the research are as follows: different publications and research papers, reports of institutions, including governmental; data from the JSC Agricultural Data Centre that provides a single database on animals and the livestock industry in Latvia [5]. The research used the Report of the Subproject "Development of Efficient Farming Models" [6]. Survey of 74 farms conducted in 2014 and representing different farm groups and all administrative regions. The survey data were analysed and compared with regard to standard technologies and cow farming solutions. Multifactor regression analysis was used to estimate the differences between different indicators in milk production [7].

Results and discussion

1. Key technologies and standard solutions on dairy farms in Latvia

Technological solutions in cow farming for milk production determine the productivity of cows and milk production economic aspects. The main ones are summarised in this section.

Cow breeds and their potential. Cows of various breeds are farmed for milk production in Latvia; yet, two breeds prevail in the herds – Latvian Brown and Black and White Holstein, which accounted for almost 73 % of the total dairy cows in 2013 (Table 1).

Table 1

Number of dairy cows and cow monitoring indicators in Latvia in 2013 [8; 9; 10]

Cow breeds	Number of dairy cows	Milk yield, kg	Fat content, %	Protein content, %	Cow live weight, kg	Relative milk yield, milk kg per 100 kg live weight
Total number of dairy cows	164 630	5 970	4.2	3.2	x	x
Incl. Latvian Brown (LBr)	60 097	5 761	4.3	3.3	540-580	990-1070
Black and White Holstein (BWH)	59 742	6 306	4.1	3.1	600-850	740-1050
Red and White Holstein (RWH)	9 306	6 127	4.2	3.2	600-850	720-1020
Danish Red (DR)	3 139	6 032	4.4	3.3	550-800	750-1100
Swedish Red and White (SRW)	1 114	6 165	4.3	3.3	550-600	1030-1120
Latvian Blue (LBl)	705	5 006	4.3	3.3	350-480	1040-1430
German Red (Angler) (AN)	633	6 003	4.3	3.3	600-700	860-1000
Crosses of various breeds	29486	5682	4.2	3.2	x	x

The highest yields were reported for the BWH group; however, the lowest fat and protein contents of milk were specific to this cow breed. Relatively low milk yields are characteristic of LBr herds, which are 3.5 % lower than the average in the country. The fat and protein contents of milk are similar for various dairy cow breeds; yet, the highest fat content of milk was observed for DR herds. The lowest milk yields were reported for LBl cows that were mostly kept for the purpose of preserving the breed. It has to be noted that cow diet factors have to be taken into account in order to objectively reflect the potential of any cow breed. For example, LBr breed cows are mostly farmed by extensive farms. To compare milk productivities of dairy cows, their relative milk productivity is calculated, which is the amount of milk a cow can produce per 100 kg live weight (Table 1, the last column). The greater the live weight of a cow, the more the cow consumes nutrients, which are not used for milk production but raise the production cost of milk, to maintain its life functions.

Housing and welfare of domestic animals. Dairy livestock are housed in heat-insulated and heat-uninsulated cowsheds. Air temperature in heat-insulated cowsheds is above 0 ºC in winter. The sidewalls of heat-uninsulated cowsheds have no windows but have openings that are covered with special curtains during the cold period. Air temperature in such cowsheds can be negative during winter. The construction cost of heat-uninsulated cowsheds is up to 40 % lower than that of heat-insulated ones, and heat-uninsulated cowsheds can be built in a shorter period. The optimum kind of housing for cows mainly depends on the number of cows to be housed in a cowshed. A tie-stall barn, which is heat-insulated, is usually used for small herds (less than 100 cows). For the loose-housing system, the recommended herd size is at least 40-50 dairy cows. Compared with tied housing, loose housing increases milk quality, cow reproduction rates and process automation opportunities as well as reduces labour intensity (approximately twofold) and the necessary investment. The key negative aspects of loose housing are greater feed consumption (by 10-15 %), a higher stress level for cows and predisposition to cow foot and hoof diseases. The kinds of loose housing in Latvia are as follows: 1) stalls; 2) combined stalls; 3) sloping floor livestock barns; 4) deep bedding barns with a separate feeding zone [11; 12].

Cow diets. The genetic potential of cows plays a great role in milk production; yet, raising the milk yield and improving the milk quality considerably depend on their diets. As pointed by A. Kureoja and T. Kaart [13], a dairy cow farming technology (the type of the cowshed, the type of housing cows indoors, diets, compliance with animal welfare standards etc.) as an exogenous factor makes a greater effect on the productivity of cows than their genetic parameters. An analysis of the factors affecting the milk yield shows that the cow diet is an essential factor that promotes or hinders the manifestation of genetic potential the most [14]. In order that cows are provided with the necessary amounts of dietary energy, protein and minerals, the cows have to be created a possibility to ingest their feed according to their physiological condition. One of the most significant criteria limiting feed intake is the cow's ability to consume dry matter. A dry matter requirement per cattle live weight unit is a relatively constant variable, but its energy content changes depending on the planned live weight gain rate. The dry matter of feed contains all the nutrients and energy of it. The higher the dry matter content in feedstuffs and the better its absorption by cattle, the higher is the nutritional value of the feedstuffs. The absorption of dry matter is affected by the quality and digestibility of feed and an optimum ratio of bulky feed and feed concentrate in the feed ration (the ratio for dairy cows should be 3 : 1-2) [14]. Dry matter requirements for and the absorption of dry matter by cattle are different and depend on many factors: the age, live weight, physiological condition, quality of feedstuffs etc.

Dairy cows need dietary energy to use protein in their organisms [15]. If a cow is short of dietary energy, after calving the cow significantly weakens and it cannot be inseminated; there are micro-abortions and the cow's milk yield declines. If a cow is overfed with diets rich in dietary energy, the cow usually gets fat, which also causes economic losses owing to its problematic insemination.

Protein requirements for dairy cows are also important; the requirements may differ owing to a cow's physiological condition (the lactation period), milk yield and live weight [15]. Two standard cow feeding patterns – extensive and intensive – are usually practised in Latvia [16].

Cow milking technologies. It has been proved in practice that it is economically efficient for farms with a herd of less than 30 cows to use bucket machine milking. If the size of a herd is 30-50 cows, it is more efficient to use milking systems with a milk pipeline in the cowshed and non-automated equipment. Larger cow herds require a milk pipeline and automated equipment or a milking parlour. The modernisation of milk production is directly associated with an increase in the herd size, which allows the farm to efficiently exploit the newest technologies and rationally use its labour. For this reason, it is recommended to establish a separate milking parlour for herds with more than 200 dairy cows (under the loose housing system). In Latvia, the most popular milking parlours are of the following types: herringbone, parallel and carousel, while tandem-type parlours are less widespread. Some farms have introduced the so called swing-over type parlours [11].

2. Effects of technologies and cow farming aspects on farm performance

In 2014, a survey of 74 farms was carried out, and its results were employed in the present analysis [17]. The survey mainly focused on potentially the most efficient farms; therefore, this survey mainly represents average or large farms and does not take into account the overall distribution of farms in the country. The group of small farms (with less than 50 dairy cows) comprised 19 of the 74 farms (26 %). The group of medium farms (with 50-100 dairy cows) had 21 farms (28 %). The group of large farms (with more than 100 dairy cows) comprised 34 farms (46 %), including 14 farms with 300 and more dairy cows and 5 farms with 500 and more dairy cows (Table 2). The small farms kept mostly LBr breed cows, while the largest herds consisted of BWH breed cows; some medium size herds had cows of various breeds (LBr, BWH and others).

The average milk yield on the small farms was approximately 6.4 thousand kg, 7.1 thousand kg on the medium farms and 7.8 thousand kg on the large farms. However, these data have relatively great standard deviations and show a weak causal relationship between the number of dairy cows and the average milk yield on the farm ($R^2 = 0.20$). It has to be noted that the acquired data are used in the context of analysis of technologies and may not be extrapolated on milk production in the whole country (Table 2).

Of the 74 farms, 42 grazed their dairy cows in pastures, while 32 did not do that. If ranking all the farms by size (by number of dairy cows), one can identify a strong relationship – the absolute majority of the farms with less than 100 dairy cows, i.e. 36 of 40 (90 %), let their cows graze. Besides, all the 19 farms with a herd of less than 50 grazed their cows. In contrast, the absolute majority of the farms with more than 100 dairy cows did not graze their cows, i.e. 28 of 34 or 82 %. The average milk yield on the farms that grazed their cows was lower than that on the farms that did not do it.

Table 2

Number of the surveyed farms by size group and their characteristics [17]

Indicators	Number of dairy cows on the farm		
	[min; 50]	[50; 100]	[100; max]
Number of farms in the group	19	21	34
Average (arithmetic) milk yield per cow, kg	6445	7114	7792
Standard deviation, kg	1348	1058	1852
Standard error, kg	309	231	318
Average (median) milk yield, kg	6200	7000	7650

Table 3

Milk yields for farm groups by type of farming cows [17]

Technology	Number of observations	Average (arithmetic), kg			Average (median) milk yield, kg
		Milk yield	Standard deviation	Standard error	
Grazing	42	6685	1221	188	6850
No grazing	32	8001	1781	315	7850

Of the 74 farms, 43 kept their cows tied, while 31 practised the loose-housing system. The farms that grazed their cows mostly used tied housing. So, of the 42 farms that grazed their cows, 35 used the tied housing technology and 7 employed the loose-housing technology. However, the farms that did not graze their cows used mostly loose housing, i.e. 24 of 32, and only 8 farms kept their cows stanchioned. The majority of the farms with less than 100 dairy cows practised the tied housing system, i.e. 32 of 40 (80 %). Among the farms in the group of farms with less than 50 cows, only 3 of 19 farms practised the loose housing system. In the group of farms with 50-100 cows, 5 of 21 farms used the loose housing system. In contrast, among the farms with more than 100 cows, 23 of 34 farms (68 %) practised loose housing.

Relationship between the kind of housing cows and milk yield. To identify the economic performance of dairy farms that use the traditional kind of housing cows (tied housing) and the traditional cow diet (grazing in summer and tie stalls in a cowshed in winter) and of dairy farms that practise the loose housing system and an unchanging diet (a heat-uninsulated cowshed throughout the year, no grazing period), 9 farms using tied housing and 8 farms using loose housing from Vidzeme region were selected for examination. The average milk yield per cow for the group of farms using loose housing was equal to 8373 kg (+572) per year, while that for the group of farms using tied housing was 5700 kg (+301), which, on the whole, was very close to the average milk yield reported in Latvia.

A Mann-Whitney U Test [18] showed that the average milk yields per cow for the farms using the tied housing system and the farms practising the loose housing system considerably differed ($\alpha = 0.01$; $n1 = 8$, $n2 = 9$). By putting forward a unilateral hypothesis ($U_{crit} = 11 > U = 4$), one can find, with a probability of 99 % ($n1 = 8$, $n2 = 9$), that the average milk yield per cow for the group of farms using loose housing is significantly higher.

For a farm using loose housing and feeding the same diet throughout the year, the absolute deviation for milk yields is within a range of 5 %. It indicates seasonally equalised milk yields for the farms using loose housing; therefore, it is simpler for them to plan business for the next periods.

For the farms with traditional tied housing, the relative indicators of average milk yield deviations are much greater and the average milk yield deviations have greater ranges. The range of average milk yield deviations was less than 5 % for only two farms. For the remaining farms, the average milk yield deviations ranged within 7-17 %.

Changes in milk yield for a farm that changes its cow housing and feeding technology from the traditional (tied) housing system that features a grazing period in summer and tied stalls in winter to loose housing and an unchanging diet (a heat-uninsulated cowshed throughout the year, no grazing period) are diverse. Under the loose housing system, the milk yield per cow increased by 5 % (to 17 kg a day) in the 1st quarter of the year, 23 % (to 21.8 kg a day) in the spring period, 34 % (to 25.9 kg a day) in the summer period and by 41 % (to 24.7 kg a day) in the autumn period, compared with tied housing [17]. If fully shifting to the loose housing system, with no grazing period, the milk yield rises, on average, by 5 kg per day, compared with the tied housing system where cows are traditionally grazed during the summer period. By employing the Wilcoxon nonparametric method for data processing, one can assume with a probability of 95 % that the milk yields under the loose housing system are considerably higher than those under the tied housing system.

Cow milking technologies. The analysed farms used the following milking technologies: bucket machine milking, pipeline milking, and herringbone, parallel, tandem and carousel milking parlours. A few farms, for experimental purposes, used milking robots (Table 4).

Table 4

Milking technology on the analysed farms [17]

Indicators	Bucket	Pipeline	Herring bone	Carousel	Tandem	Parallel
Number of farms in the group	6	42	11	8	3	2
Average number of dairy cows	13	97	175	440	259	408
Average milk yield per cow, kg	5987	6925	8076	8581	6600	9333
Standard deviation, kg	1088	1236	1862	2263	1039	1885
Standard error, kg	444	191	562	800	600	1333

The small farms used a simple milking technology – bucket machine milking. The selected farms were represented by six such farms with, on average, 13 cows per farm. All these farms practised the tied housing system, and their average milk yield was approximately 6 000 kg. The most widespread milking technology was pipeline milking, which was mostly used by relatively small farms (with, on average, 97 cows) using the tied housing system. This milking technology was used by 42 of the 74 farms. A medium high milk yield was observed for these farms – about 7000 kg. The loose housing farms mostly used two technologies – herringbone and carousel milking parlours – 11 and 8 farms, respectively. Both technologies were used by intensive farms; the average milk yield for the farms having herringbone parlours was 8.1 thousand kg, while for those having carousel milking parlours it was 8.6 thousand kg. In the group of large farms, herringbone parlours were used by relatively smaller farms (with, on average, 175 dairy cows), while the carousel milking technology was typical for relatively larger farms (with, on average, 440 dairy cows). Some farms of various sizes from the group of large farms used tandem and parallel milking technologies (3 and 2 farms, respectively).

The majority or 61 of the 74 farms milked their cows twice a day; yet, 13 farms practised three times per day milking. Milking cows three times per day was practised by mostly large farms with, on average, 352 dairy cows; yet, a significant standard deviation was observed for these farms.

Table 5

Distribution of the analysed farms by frequency of milking [17]

Frequency of milking	Number of observations	Number of dairy cows			Average (arithmetic), kg		
		Number	Standard deviation	Standard error	Milk yield	Standard deviation	Standard error
All farms	74	154	160	19	7254	1617	188
Twice a day	61	112	108	14	6875	1296	166
Three times a day	13	352	217	60	9035	1829	507

Of the 13 farms that milked their cows three times a day, only 2 grazed their cows, and such a practice may be rather regarded as an exception. The farms with carousel parlours milked their cows mostly three times a day – of the 8 farms having a carousel parlour, 5 practised three times per day milking. Among the analysed farms, three times per day milking was practised by 3 of the 11 farms with herringbone-type milking equipment, one of the 2 farms with parallel-type milking equipment, 3 of the 42 farms having the pipeline milking technology and one small farm of the 6 farms exploiting the bucket machine milking technology. The fact that three times per day milking was specific to large and intensive farms was reflected in their milking yields. The average milk yield of all the analysed farms was equal to 7254 kg. However, the farms practising three times per day milking had an average milk yield of 9035 kg. Higher milk yields for farms milking their cows three times per day were not associated with only the frequency of milking but also with more intensive feeding.

To forecast the productivity level of dairy cows – milk yield per day (kg), a multifactor analysis was performed; the analysis employed variables (x_i) that show the quality and quantity of feed: dry matter absorption capacity per day x_1 (kg), dietary energy requirement per day x_2 (MJ) and protein requirement per day x_3 (kg) according to the planned productivity level and cows' live weight (Table 6). The absolute value of the correlation coefficient calculated R^2 = 0.867 indicates a strong causal relationship, while the determination coefficient of 0.751 means that 75 % of weight gain by young cattle may be explained by the linear regression model (p < 0.05).

Table 6

Coefficients of multifactor statistical regression analysis for the relationship between the milk yield and cow diets [7, 17]

Model/ indicators	Unstandardized Coefficients		Standardized Coefficient Beta	t	Sig.
	B	Std. Error			
(Const)	-5.062	0.563		-8.993	0.000
Daily dry matter absorption capacity, kg	-1.157	0.114	-0.473	-10.133	0.000
Daily dietary energy requirement, MJ	0.227	0.015	1.291	15.183	0.000
Daily protein requirement, kg	1.852	0.604	0.173	3.068	0.004

So, the following linear regression equation describing the milk yield changes with regard to key cow diet components may be developed (1):

$$y = -5.062 - 1.157 \times x_1 + 0.227 \times x_2 + 1.852 \times x_3 \qquad (1)$$

where y – milk yield a day, kg;
x_1 – daily dry matter absorption capacity, kg;
x_2 – daily dietary energy requirement, MJ;
x_3 – daily protein requirement, kg.

Conclusions

1. Technological solutions in cow farming for milk production determine the productivity of cows and milk production economic aspects. The key solutions are as follows: the cow breeds and their potential, conditions and technologies for cow farming, cow diets and the kind of cow milking. In Latvia, cattle herds are dominated by two breeds: Latvian Brown and Black-and-White Holstein, which accounted for almost 73 % of the total dairy cows in 2013. The highest yields were reported for Black-and-White Holstein cows; however, the lowest fat and protein contents of milk were specific to this cow breed. Relatively low milk yields are characteristic of Latvian Brown cows, which are 3.5 % lower than the average in the country; yet, their fat and protein contents are higher.
2. In Latvia, dairy livestock are kept in heat-insulated and heat-uninsulated cowsheds. The optimum kind of housing for cows mainly depends on the number of cows to be housed in a cowshed. Two kinds of housing for cows are the most widespread: tied and loose. Cow diets are the most important factor promoting or hindering the manifestation of genetic potential. The dry matter absorption by cows and meeting the requirements of dietary energy and protein are of great importance. In Latvia, farmers use diverse milking technologies, which are determined by the number of cows in a herd.
3. An examination and a survey of 74 dairy farms of various sizes revealed that medium size farms (with 50-99 cows) and large farms (with more than 100 cows) reached the highest milk yields. The average milk yield of the farms that graze their dairy cows is lower than that of the farms not grazing their cows. An analysis of the selected herds showed that the average annual milk yield per cow was higher for the group of loose housing farms than that for the group of tied housing farms.
4. The most widespread milking technology was pipeline milking, which was mostly used by relatively small farms. A medium high milk yield was observed for these farms – about 7000 kg. The loose housing farms mostly used two technologies – herringbone and carousel milking parlors, which were used by intensive farms, allowing reaching average milk yields of 8.1 and 8.6 thousand kg, respectively. The majority or 61 of the 74 farms milked their cows twice a day;

yet, 13 farms practiced three times per day milking, which allowed achieving 25 % higher milk yields per cow owing to more intensive feeding as well.

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