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Effect of technical and biological potential on dairy production development

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Abstract. Dairy production ranks among the most important agricultural activities in many European countries. The general potential of dairy production is created by technical, biological, economic and technological potential. Each unit potential decides about global effectiveness of dairy production including farm as well as national scale. The paper aimed at analyzing importance of some potential in the dairy production development. The significance of technical and biological potential in the dairy production development was indicated, taking into account data coming from Estonian and Polish farms as well as national dairy production systems in two European countries.

Key words: biological potential, dairy production, development, technical potential.

INTRODUCTION

Dairy production is one of the most important agricultural activities in almost all EU countries and in the EU as a whole, both in the previous decades (Viaene & Gellynck, 1997) and at the present time. Every day billions of people around the world consume milk and dairy products.

To provide access to milk and dairy products for consumers it is necessary to create effective dairy system including farms, processing plants, transport means, distribution network and many significant links in the dairy value chain.

Effectiveness of dairy system and its particular parts depends on many factors, including not only assessment of technical and technological solutions but also energy approach (Ahokas et al., 2013). The farm dairy production is an excellent example to show some trends to make dairy production more and more effective.

For the last 50 years, the dairy sector in most developed countries has shifted towards larger herds and greater annual milk production per cow. The driving force in this development has been the need to adopt technologies that require large capital investments and hence depend on larger herds to be profitable. On the other hand, most milk in developing countries is still produced in traditional small-scale systems with little or no mechanization or technological innovations (Gerosa & Skoet, 2013).

The mentioned mechanization, technological solutions, as well as annual milk production per cow and profitability express different kind of potential, which can be recognized in the farm dairy production (Gaworski et al., 2013). Of course it is

possible to put some questions concerning significance of technical, technological, biological and economic potential, respectively in the assessment of dairy production development. According to the problem stated, the paper presents results of some analyses, where different kind of the potentials in dairy production were compared.

MATERIALS AND METHODS

To discuss significance of some kind of potential in dairy production, available statistical data edited by Central Statistical Office and organizations responsible for monitoring of dairy production in regional and national scale were collected.

Because the term 'potential' is used in relation to some aspects referring to dairy production, so it can be important to give some more deep explanations. We would like to propose the following meaning and scope of research concerning the mentioned term potential in farm dairy production:

- technical potential – set of technical equipment needed to operate herd of cows and milk stream in the farm, including construction complexity;
- technological potential – methods, how dairy cows are kept in the barn, including tie system and loose housing system;
- biological potential – set of data describing dairy cows, i.e. annual milk yield per cow, cows herd size, amount of produced milk;
- economic potential – set of data deciding about economic effectiveness of farm dairy production, e.g. ex-farm milk price, dairy production costs.

The major stage in the undertaken considerations comes down to selection or elaboration of some indices to compare the mentioned potentials in farm dairy production.

The detailed investigations were carried out on the base of data coming from dairy sector in Estonia and Poland. Data concerning two European countries were taken into account to show differences between the regions, where dairy production plays important role in food economy development.

RESULTS AND DISCUSSION

To analyse some relationships between biological potential, economic potential and some aspects of technical potential utilization, the following two indices proposed by Gaworski & Dumas (2012) were used, i.e. index of lost functional benefits (i_f) and index of lost economic benefits (i_e).

The i_f index can be calculated according to the following equation:

$$i_f = \left(1 - \frac{p_i}{p_{\max}}\right) \cdot 100\% \qquad (1)$$

where: i_f – index of lost functional benefits [%]; p_i – milk production in the given month [t·month^{-1}]; p_{max} – maximum milk production per month during 12-months period [t·month^{-1}].

The i_f index expresses effectiveness of milking system utilization defined as relation between amount of milk for milking in the given period and amount of milk,

which can be milked in the month with maximum milk production. When the milking installations are used in the months with lower (than maximum) milk production it means that technical potential of the milking installations is not fully utilized. Such situation can be interpreted as lost benefits, when the technical potential is utilized.

However the i_e index can be calculated according to the following equation:

$$i_e = \left(1 - \frac{v_i}{v_{\max}}\right) \cdot 100\% \tag{2}$$

where: i_e – index of lost economic benefits [%]; v_i – pecuniary value of milk produced in the given month [euro]; v_{max} – maximum pecuniary value of milk produced per month during 12-months period [euro].

The proposed indices were calculated for Estonian and Polish conditions of milk production including data for twelve months (January-December) analysed in the period 2011–2013 (Table 1). According to materials published by Statistical Offices in Estonia and Poland, the data concerning amount of milk collected per month were included in the analysis (Table 1). Values of the calculated indices for each month and year were taken to find average values i_f and i_e for particular months (Table 2).

Table 1. Set of data describing biological and economic potential of dairy production in Estonia and Poland for 2011–2013 period

Country	Month	Milk collected [t·10^3·month^{-1}]			Ex-farm milk price [euro·t^{-1}]			Milk pecuniary value [euro·10^6·month^{-1}]		
		Year			Year			Year		
		2011	2012	2013	2011	2012	2013	2011	2012	2013
Estonia	Jan.	53.8	54.5	57.1	312.6	327.3	321.9	16.82	17.84	18.38
	Feb.	48.4	51.2	52.5	313.2	328.9	327.3	15.16	16.84	17.18
	Mar.	53.5	55.9	59.2	324.0	327.1	329.8	17.33	18.29	19.52
	Apr.	53.0	54.7	58.1	329.5	313.3	325.4	17.46	17.14	18.90
	May	55.9	57.1	61.2	329.1	296.4	326.5	18.40	16.93	19.98
	Jun.	54.2	56.7	60.3	326.9	285.2	327.9	17.72	16.17	19.77
	Jul.	55.3	58.7	61.9	325.8	273.3	330.8	18.02	16.04	20.48
	Aug.	57.0	58.5	61.4	324.9	273.7	333.2	18.52	16.01	20.46
	Sept.	54.3	54.9	58.8	324.6	277.7	344.9	17.62	15.25	20.28
	Oct.	52.6	54.6	58.2	320.4	285.4	352.8	16.85	15.59	20.53
	Nov.	50.9	52.7	56.7	320.4	299.9	361.4	16.31	15.80	20.49
	Dec.	53.4	55.6	60.3	320.0	317.1	375.0	17.09	17.63	22.61
Poland	Jan.	724.2	791.6	782.4	279.0	308.1	300.0	202.04	243.86	234.68
	Feb.	663.8	738.7	724.9	281.9	309.9	301.5	187.15	228.95	218.55
	Mar.	753.3	820.3	813.1	291.0	305.0	304.4	219.19	250.19	247.51
	Apr.	753.0	854.7	816.9	292.3	293.3	305.4	220.10	250.72	249.47
	May	842.5	905.9	891.4	288.8	286.6	305.4	243.36	259.59	272.26
	Jun.	847.7	869.4	859.7	289.6	281.9	308.2	245.50	245.05	264.97
	Jul.	829.7	867.9	892.0	289.5	279.3	315.2	240.20	242.41	281.13
	Aug.	820.7	860.7	867.1	292.1	281.3	321.5	239.76	242.10	278.73
	Sept.	785.5	809.9	822.8	294.3	283.5	337.6	231.13	229.61	277.73
	Oct.	774.1	790.0	816.5	298.7	289.9	348.4	231.27	229.01	284.43
	Nov.	728.2	730.2	768.2	307.9	299.9	373.3	224.25	218.94	286.79
	Dec.	760.2	762.6	810.1	313.8	300.6	378.7	238.55	229.23	306.77

Source: Central Statistical Offices in Poland and Estonia and own calculations

Table 2. Index of lost functional benefits (i_f) and index of lost economic benefits (i_e) calculated for Estonia and Poland including 2011–2013 period

Country	Month	Index of lost functional benefits i_f [%]				Index of lost economic benefits i_e [%]			
		Year			Average	Year			Average
		2011	2012	2013		2011	2012	2013	
Estonia	Jan.	5.6	7.2	7.8	6.8	9.2	2.5	18.7	10.1
	Feb.	15.1	12.8	15.2	14.4	18.2	7.9	24.0	16.7
	Mar.	6.1	4.8	4.4	5.1	6.4	0.0	13.7	6.7
	Apr.	7.0	6.8	6.1	6.7	5.7	6.3	16.4	9.5
	May	1.9	2.7	1.1	1.9	0.7	7.5	11.6	6.6
	Jun.	4.9	3.4	2.6	3.6	4.3	11.6	12.5	9.5
	Jul.	3.0	0.0	0.0	1.0	2.7	12.3	9.4	8.1
	Aug.	0.0	0.3	0.8	0.4	0.0	12.5	9.5	7.3
	Sept.	4.7	6.5	5.0	5.4	4.8	16.6	10.3	10.6
	Oct.	7.7	7.0	6.0	6.9	9.0	14.8	9.2	11.0
	Nov.	10.7	10.2	8.4	9.8	12.0	13.6	9.4	11.6
	Dec.	6.3	5.3	2.6	4.7	7.7	3.6	0.0	3.8
Poland	Jan.	14.6	12.6	12.3	13.2	17.7	6.1	23.5	15.8
	Feb.	21.7	18.5	18.7	19.6	23.8	11.8	28.8	21.4
	Mar.	11.1	9.5	8.8	9.8	10.7	3.6	19.3	11.2
	Apr.	11.2	5.7	8.4	8.4	10.3	3.4	18.7	10.8
	May	0.6	0.0	0.1	0.2	0.9	0.0	11.3	4.0
	Jun.	0.0	4.0	3.6	2.5	0.0	5.6	13.6	6.4
	Jul.	2.1	4.2	0.0	2.1	2.2	6.6	8.4	5.7
	Aug.	3.2	5.0	2.8	3.7	2.3	6.7	9.1	6.1
	Sept.	7.3	10.6	7.8	8.6	5.9	11.5	9.5	9.0
	Oct.	8.7	12.8	8.5	10.0	5.8	11.8	7.3	8.3
	Nov.	14.1	19.4	13.9	15.8	8.7	15.7	6.5	10.3
	Dec.	10.3	15.8	9.2	11.8	2.8	11.7	0.0	4.8

Source: own calculations

The average values of the index of lost functional benefits (i_f) and the index of lost economic benefits (i_e) were presented together including the radar graphs for Estonia (Fig. 1) and Poland (Fig. 2).

For Estonia and Poland the lowest average value of the index of lost functional benefits (i_f) were found in August and May, respectively. However the lowest average value of the index of lost economic benefits (i_e) can be recognized in both countries in May.

When we compare visually the radar graphs on the Figs 1 and 2 as well as detailed values of the discussed indices it is possible to indicate considerable bigger area covered by the graphs for Poland. Such results suggest higher possible losses of functional and economic benefits connected with use of technical potential for milking on the dairy farms. At the same time results of the analyses confirm significance of stability of dairy production and needs to implement proper management practices in dairy production to keep possibly balanced milk flow in the dairy system.

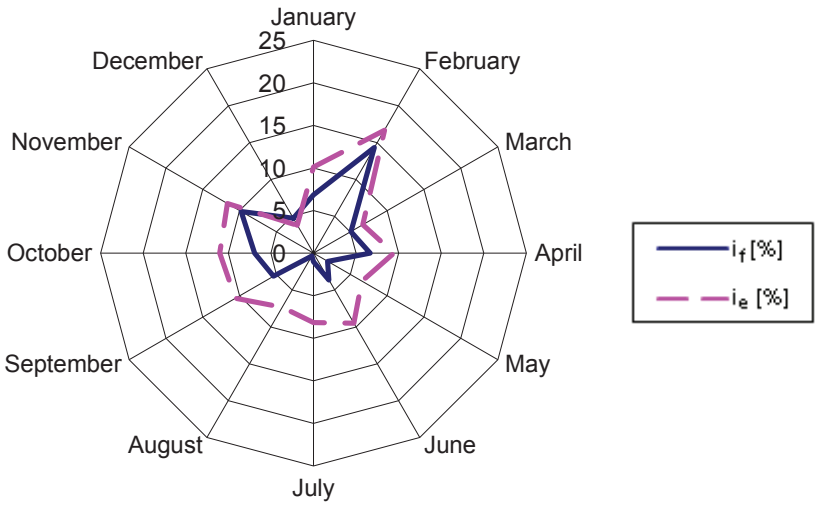

Figure 1. Index of lost functional benefits (i_f) and index of lost economic benefits (i_e) calculated for Estonia (Source: own elaboration).

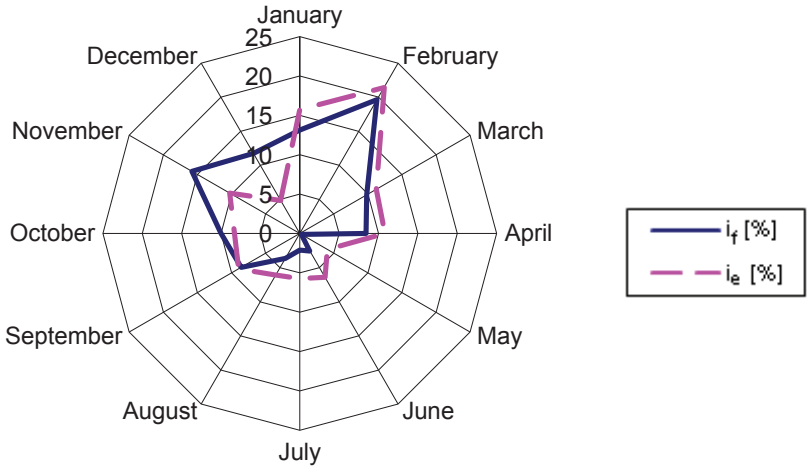

Figure 2. Index of lost functional benefits (i_f) and index of lost economic benefits (i_e) calculated for Poland (Source: own elaboration).

The next step of the investigations included analysis of some factors deciding about differences in biological potential between dairy farm, which can show effect on technical potential, especially milking systems load and capacity. Basing on data coming from Polish dairy system covering 16 regions (voivodeships) with 19,916

herds considered, dairy cows herd size with annual milk yield per cow have been collated. The result of the taken together data for 2012 was presented on the Fig. 3.

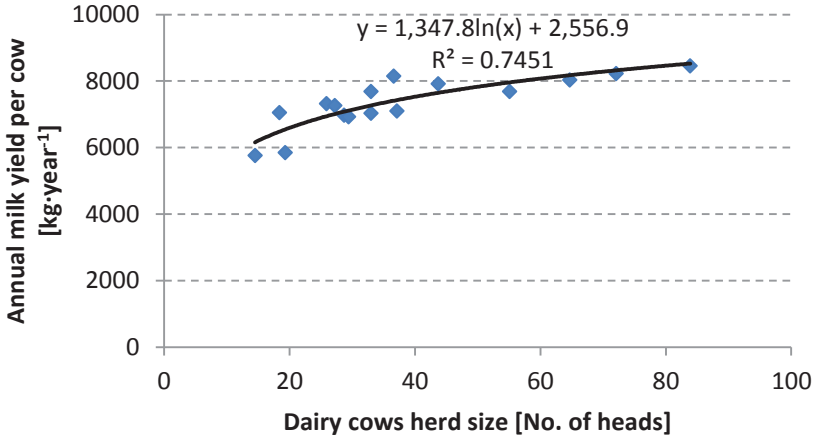

Figure 3. Relationship between annual milk yield per cow and dairy cows herd size for Polish dairy farms under recording system in 2012 (Source: own calculations on the base of data coming from Polish Federation of Cattle Breeders and Dairy Farmers).

It is possible to indicate (Fig. 3) that annual milk yield per cow increases with higher number of dairy cows in the herd. The mentioned relationship can be described by curve with coefficient of determination (R^2) amounted to more than 0.7. Especially for bigger cow herd sizes (more than 40 cows per herd) the increase tendency bases on the points (data) not very distributed around the curve.

Extending discussion concerning the given above relationship there is possible to indicate some additional effects and suggestions. The bigger and bigger size of dairy herds is accompanied by higher annual milk yield per cow and at the same time necessity to use higher capacity milking systems. It means that higher capacity milking systems are used to operate animals characterized by higher annual milk yield. As a result it is possible to indicate that higher technical potential is responsible for operation of higher biological potential. The higher technical potential concerning milking systems is characterized by modern solutions and such modern technical solutions are used on the farms with higher biological potential of cows. The given above considerations confirm importance and advantages coming from simultaneous implement of different kind of progress in agriculture and agricultural activities (Gaworski, 2006).

To develop problem of technical potential modernity in dairy production we have analyzed changes in the number of different kind of milking installations and equipment for farm milk cooling. The data coming from Polish dairy system were included, where each few years detailed statistical monitoring of farms is carried out on the base of questionnaire.

In the field of milking the data concerning the following type of solutions: bucket milking machines and pipeline milking machines were included. However in the field of milk cooling such type of solutions was taken into account: coolers of milk in

buckets and tank milk coolers. Including total number of milking installations and cooling systems in Polish dairy farms we have calculated share of more modern solutions (pipelines milking machines and tank milk coolers) in each group of considered technical equipment for 1996, 2002 and 2010.

The results of the carried out calculations (Fig. 4) show considerable differences in the share of modern technical solutions in relation to total number of the given groups of technical equipment. Generally there is possible to note increase in the share of pipelines milking machines and tank milk coolers in the analyzed period. But there can be indicated higher increase in the share of modern equipment for cooling in comparison with increase in the share of pipeline milking machines. We can ask about reason of such tendency. It seems to be important that higher share and changes concerning tank milk coolers result from their lower investment costs (in comparison with milking installation), possibilities to reduce (safe) energy consumption (in comparison with coolers of milk in buckets), needs to meet milk high quality standards and keep raw milk for 2–3 days in the farm, as a result of milk purchase organization.

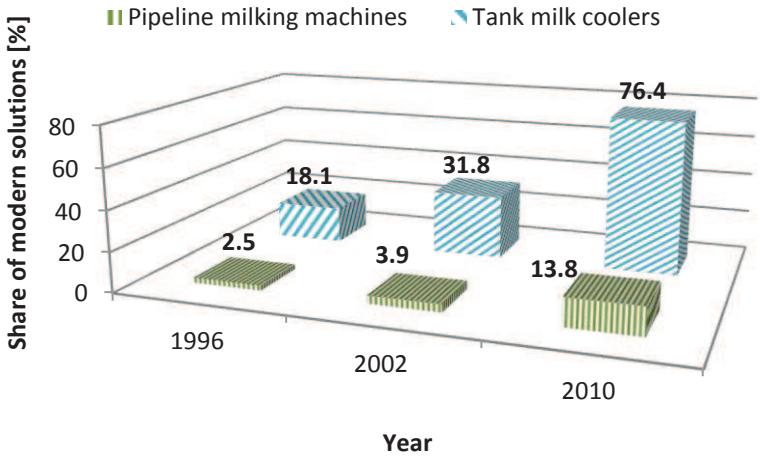

Figure 4. Share of modern technical solutions in relation to total number of milking machines and milk coolers in Poland in the years 1996, 2002 and 2010 (Source: own elaboration on the base of Central Statistical Office data, Poland).

CONCLUSIONS

Dairy production constitutes area, where some indices connected with assessment of different kind of potential can be proposed and used for comparisons between dairy production regions. Results of the carried out analyses show possible losses of functional and economic benefits connected with use of technical potential for milking. Stabile (month by month) dairy production in terms of amount and value of milk collected from the farms is one of the most important factors, which confirm premise for effective use of technical potential (equipment) in dairy production.

The included indices in the analyses show general approach to the important problem of effectiveness of milking systems utilization. At the same time, the indices

can be one of the propositions to carry out more deep analyses concerning factors affecting development and assessment of milking systems and their technical potential against a background of biological potential of dairy cow herds.

When dairy farms are implemented with more and more modern technical solutions for milking there is simultaneous improvement of dairy cow herds expressed by annual milk yield per cow and other factors expressing biological advance.

Each part of the dairy system constitutes field of detailed research considerations to assess previous and current development as well as to show premises for further improvement.

REFERENCES

Ahokas, J., Mikkola, H., Jokiniemi, T., Rajaniemi, M., Schäfer, W., Rossner, H., Poikalainen, V., Praks, J., Veermäe, I., Frorip, J. & Kokin, E. 2013. ENPOS – Energy positive farm. *Agronomy Research* **11**(2), 523–527.

Central Statistical Office, 2012. Warsaw, Poland.

Gaworski, M. 2006. Analysis of different forms of advance in dairy production. *Veterinarija ir Zootechnika* **35**(57), 48–52.

Gaworski, M. & Dumas, F. 2012. Assessment of technical potential use in dairy production on an example of comparative analysis covering French and Polish conditions. *Ann. Warsaw Univ. Life Sci. – SGGW, Agricult.* **60**, 89–96.

Gaworski, M., Leola, A. & Priekulis, J. 2013. Comparative analysis on effectiveness of AMS use on an example of three European countries. *Agronomy Research* **11**(1), 231–238.

Gerosa, S. & Skoet, J. 2013. Milk availability: Current production and demand and medium-term outlook. [In:] Milk and dairy products in human nutrition. *FAO*, Rome, 11–40.

Polish Federation of Cattle Breeders and Dairy Farmers, Statistical Office, Warsaw, 2013.

Viaene, J. & Gellynck, X. 1997. Competitiveness of the dairy industry in EU and challenges for new member states. [In:] Integration of the dairy sector with European Union, challenges and chances for Central Europe. Warsaw Agricultural University – SGGW, Warsaw, 11–24.