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ANALYSIS OF ELECTRICAL ENERGY CONSUMPTION IN TECHNOLOGICAL LINES IN CIECHANOW DAIRY COOPERATIVE

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ABSTRACT

The paper deals with analysis of electrical energy consumption by technological lines of particular dairy products in Ciechanow Dairy Cooperative in 2011. Ciechanow Dairy Cooperative is an average establishment on account of size. The establishment produces milk, sour cream, cheese and curd, butter, homogenised cheese and yoghurt. Based on data provided by the cooperative, actual indexes of electrical energy consumption were calculated and compared with the values obtained in dairy cooperatives of the selected EU states. In 2011, the average value of the index of electrical energy consumption in Ciechanow Dairy Cooperative was $46.5 \text{ kWh} \cdot 10 \text{ hl}^{-1}$ of the processed milk. This value is considerably lower than the average one reported in dairy cooperatives in Poland. The highest amount of electrical energy consumed for milk and milk drinks production is in Sweden, the lowest in Poland and Denmark.

Introduction

Agri-food processing establishments have specific properties which result from the amount and seasonality of processed raw materials, production technology, degree of mechanization of production operations and spatial development (Wojdalski et al., 2006). Consumption of energy carriers in these establishments depends on many factors, among which there are: thermal and physical properties of raw materials, requirements for the product, production technology, size and production structure, technical equipment, degree of production operation mechanization, degree of using the capacity and production organization (Wojdalski et al., 2012). Approximately 80% of the energy consumed by dairy cooperatives is energy which comes from fuel combustion and processing to the form of steam and warm water. The remaining energy consumption is electrical energy necessary to maintain the operation of production lines, cooling systems, ventilation and lighting (Mierzejewska et al., 2011). In the dairy industry, production lines for condensed milk and powdered milk are generally considered to consume the highest amount of heat and energy (BAT, 2005). Based on the research on the technological lines devices on account of electrical energy consumption, spots of big losses of these energy carriers may be easily determined and current indices of unit electrical energy consumption may be improved (Janus, 2005).

The index of unit consumption of electrical energy is used for determination of energy management in processing in the food industry. It is a relation of electrical energy consumed in the processing to the produced amount of products (Domagała, 1986, Wojdalski et al., 1998). Knowledge of indices of energy consumption enables technologists to carry out comparative assessment on account of processing in various industrial establishments (Janus, 2004) and for designers it is indispensable for designing energy of technological lines (Domagała, 1986). According to Wojdalski et al. (2012) the knowledge of the value of indices of energy consumption in particular technological processes is significant on account of rational energy management of an establishment.

Objective, scope and methodology of research

The objective of the research was to analyse electrical energy consumption by production lines of particular dairy products in 2011. The research material comprised data provided by Ciechanow Dairy Cooperative. The dairy cooperative in Ciechanow is equipped with the following technological lines: a milk processing room, continuous method production line for homogenised cheese, curd cheese production room, cheese production room (boiling room, salting room, ripening room) a continuous line for butter production, urban division.

The scope of the research covered:

- determination of electrical energy inputs per unit indices of electrical energy consumption by technological lines in 2011,
- determination of electrical energy consumption ($\text{kWh} \cdot 10\text{hl}^{-1}$ of processed milk) in particular months of 2011,
- comparison of indices of electrical energy consumption with the values obtained in dairy cooperatives in Poland and in the selected EU states.

Results of the research

Based on the results of measurements of electrical energy amounts on technological lines and the mass of the final product indices of unit electrical energy consumption were calculated and presented in table 1.

In 2011 Ciechanow Dairy Cooperative produced 5, 485, 243.6 litres/kilos of products. A considerable amount of 2, 930, 851.25 litres constituted milk (figure 1a and 1b).

From among all analysed production lines, the highest value of unit electrical energy consumption of $40 \text{ kWh} \cdot 10\text{hl}^{-1}$ was reported on the cheese processing and forming line, and the whey line. A high value of energy inputs per a unit index of energy was reported on the buttering and the yoghurt line and 30% and 36% on the sour cream line, milk reception line, raw milk tanks. The lowest value of the electrical energy consumption index of $2 \text{ kWh} \cdot 10\text{hl}^{-1}$ was reported on the line for packing in cubes and on the line of fresh cheese, thermized cheese and cream (table 1). According to Marks et al. (2007) differences in the amount of energy inputs result from different capacities, amount and quality of the purchased raw material and the condition of a machinery park in establishments.

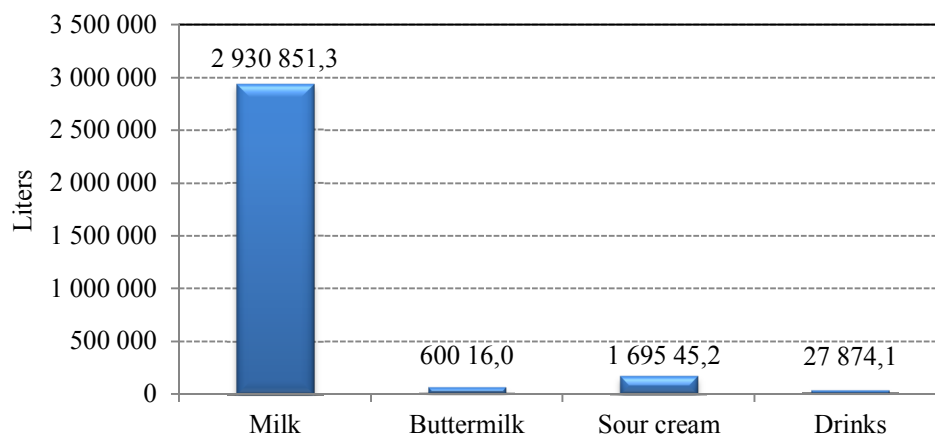


Figure 1a. Type and size of production in Ciechanow Dairy Cooperative in 2011

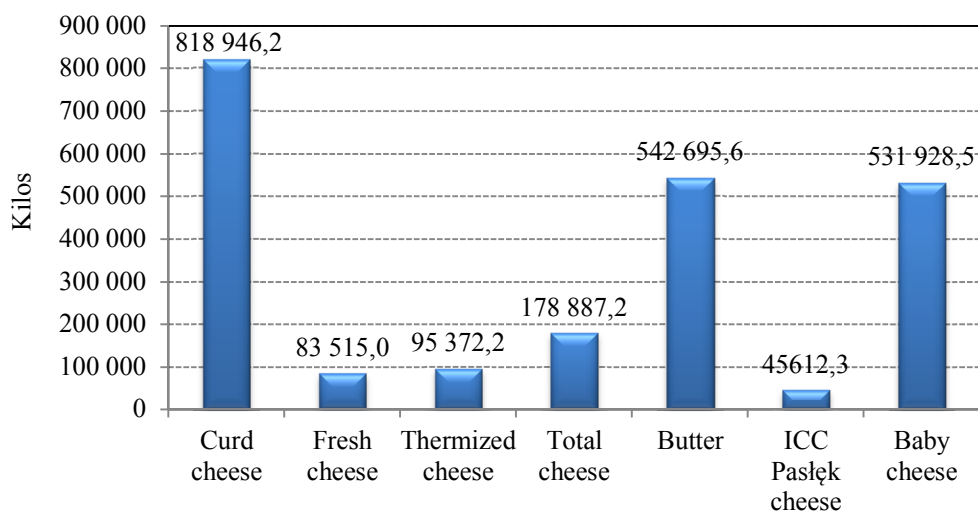


Figure 1b. Type and size of production in Ciechanow Dairy Cooperative in 2011

Table 1
Unit electrical energy consumption (kWh·10 hl⁻¹ of the processed milk) by technological lines in Ciechanow Dairy Cooperative in 2011

Technological lines	Unit index of energy consumption (kWh·10 hl ⁻¹ of the processed milk)
Milk reception line, raw milk tanks	23.3
Line for pouring milk into cartons	11
Line for fresh cheese, thermized cheese and cream	6
Line for fresh cheese, thermized cheese and cream	6
Buttering line	32
Buttermilk line	16
Yoghurt and 30% and 36% sour cream line	30
Processing line for curs and pressing, whey line	10
Line for packing into cubes	2
Line for packing immature cheese and ripening room no. 1	17
Processing and forming line for curd cheese, whey line	40
Confection line for matured cheese and cheese ripening room no. 2	7

According to the analysis of the Polish dairy sector (FAPA, 1998), the unit electrical energy consumption is between 0.6 to 0.8 MWh per 1 tonne of a product. When comparing indices of electrical energy consumption in the selected countries of the European Union and in Ciechanow Dairy Cooperative one may state that the highest amounts of energy for milk and milk drinks production are incurred in Sweden and the lowest in Poland and Denmark. In Ciechanow Dairy Cooperative the index of energy concerning milk and milk drinks production is within the range stated for Poland. The highest amounts of energy for cheese and whey production are incurred in Finland (Table 2).

Table 2
Consumption of electrical energy (kWh·t⁻¹ of processed milk) in the European Union states and in Ciechanow Dairy Cooperative (BAT, 2005)

Products	Sweden	Denmark	Finland	Poland
Milk, milk drinks	0.11-0.34	0.07-0.09	0.16-0.28	0.05-0.06
Cheese, whey	0.15-0.34	0.12-0.18	0.27-0.82	0.06
Powdered milk, cheese or/and milk drinks	0.18-0.65	0.3-0.71	0.28-0.92	0.05-0.09

Source: BAT, 2005

Figure 2 presents average values of the index of electrical energy consumption in Ciechanow Dairy Cooperative in particular months of 2011. Average value of the electrical energy consumption index in the Dairy Cooperative in Ciechanów was 46.5 kWh·10 hl⁻¹ of

the processed milk. In January and February, the index of electrical energy consumption was at the same level. From March to May the lowest energy consumption was reported. From June to September a gradual increase of energy consumption took place. In November, the value of unit index of energy consumption was the highest.

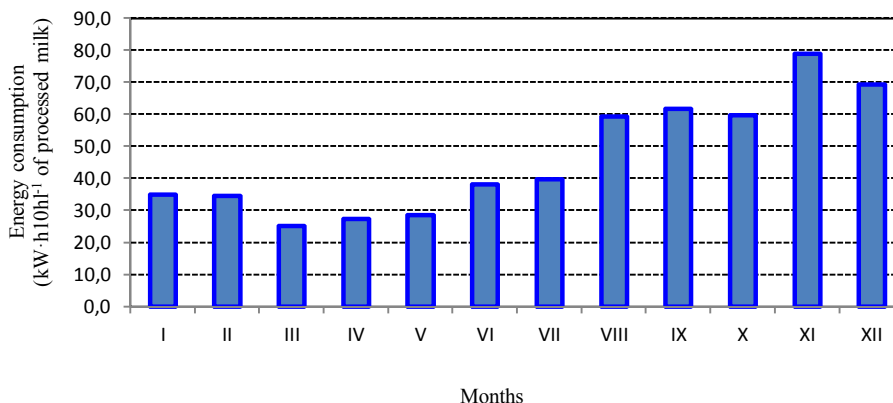


Figure 2. Average electrical energy consumption (kWh·10 hl⁻¹ of the processed milk) in Ciechanow Dairy Cooperative in particular months of 2011

Wojtalski (2012) stated that the average value of the energy efficiency index in dairy establishments is 25 kWh·10 hl⁻¹ of milk. According to Trojanowska (2010) the index of electrical energy consumption in dairy establishments fluctuates within 55 to 88 kWh·10 hl⁻¹ of milk at the average value of 74 kWh·10 hl⁻¹ of the processed milk and its value is related to the season of the year.

Participation of electrical energy in the establishment's index of unit energy consumption in the entire dairy industry reaches at the average 15% and is 80 kWh·10hl⁻¹ of the processed milk. The increased consumption of electrical energy is characteristic for establishments producing butter and powdered milk as well as ice-creams (BAT, 2005).

Conclusion

1. Based on the research on technological line devices on account of unit indices of electrical energy consumption it was found out that in 2011 the highest amount of energy was consumed on: the cheese processing and forming line, whey line (40 kWh·10 hl⁻¹), buttering line (32 kWh·10 hl⁻¹), yoghurt line and 30% and 36% on the sour cream line (30 kWh·10 hl⁻¹), milk reception line, raw milk tanks (23.3 kWh·10 hl⁻¹). The unit index of electrical energy consumption reached the lowest value on the line for packing in cubes (2 kWh·10 hl⁻¹).

2. In Ciechanow Dairy Cooperative an average unit index of energy consumption is lower than the average reported in Poland. In 2011 average value of index of electrical energy consumption was $46.5 \text{ kWh} \cdot 10 \text{ hl}^{-1}$ of the processed milk.
3. Electrical energy consumption, similarly to water consumption depends, inter alia, on the production profile. Dairy Cooperative in Ciechanów does not produce powdered milk, which may result in a considerably lower index of energy consumption in comparison to other national cooperatives.

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ANALIZA ZUŻYCIA ENERGII ELEKTRYCZNEJ NA LINIACH TECHNOLOGICZNYCH W CIECHANOWSKIEJ SPÓŁDZIELNI MLECZARSKIEJ

Streszczenie. W pracy przedstawiono analizę zużycia energii elektrycznej przez linie technologiczne poszczególnych przetworów mlecznych w Ciechanowskiej Spółdzielni Mleczarskiej w 2011 roku. Ciechanowska Spółdzielnia Mleczarska pod względem produkcji jest zakładem średniej wielkości. W zakładzie produkuje się: mleko spożywcze, śmietanę, sery i twarogi, masło, serki homogenizowane oraz jogurty. Na podstawie danych udostępnionych przez zakład obliczono rzeczywiste wskaźniki zużycia energii elektrycznej i porównano z wartościami osiąganymi w zakładach mleczarskich wybranych krajów Unii Europejskiej. W 2011 roku średnia wartość wskaźnika zużycia energii elektrycznej w Ciechanowskiej Spółdzielni Mleczarskiej wyniosła $46,5 \text{ kWh} \cdot 10 \text{ hl}^{-1}$ przetwarzanego mleka. Wartość ta jest znacznie niższa od przeciętnej notowanej w zakładach mleczarskich w Polsce. Na produkcję mleka i napojów mlecznych największe ilości energii elektrycznej zużywane są w Szwecji, a najmniejsze w Polsce i Danii.

Słowa kluczowe: zużycie energii, linia technologiczna, energia elektryczna, zakład mleczarski