*TEKA Kom. Mot. Energ. Roln. – OL PAN, 2010, 10, 233–238*

# DESCRIPTION OF SELECTED PHYSICOCHEMICAL PARAMETERS OF DRIED BEET PULP

Elżbieta Kusińska, Paweł Sobczak, Kazimierz Zawiślak, Jan Malec*

Department of Food Engineering and Machinery, University of Life Sciences in Lublin
*Institute of Sugar Industry in Leszno
e-mail: elzbieta.kusinska@up.lublin.pl

**Summary.** The paper presents the energy requirements and efficiency of the process of disintegration of dried beet pulp, and the results of determinations of selected physical and chemical properties of the obtained product. The test material was beet pulp from the Cukrownia Werbkowice sugar plant, dried to the moisture level of ca 3%. In the course of disintegration in a hammer mill with the screen of 1.5 mm mesh size the largest amount of fine silt fraction was obtained, 0.2, 0.1 mm from the screens and from the bottom, and 0.5 mm from the screen (ca 45%). The coarse fraction constituted only about 7%. The process of disintegration using 3 mm mesh screen was characteristic. In that case the distribution of the individual fractions was almost uniform. The finest fraction had the highest content of contaminants and harmful elements. At the same time, that fraction had the lowest content of protein and large amounts of ash. The energy requirements of the process of disintegration were the lowest when the 3 mm mesh screen was used, while the efficiency of the process increased.

**Key words:** beet pulp, energy requirements, physical properties, chemical analysis

## INTRODUCTION

During the sugar campaign, the Polish sugar plants produce ca 3 million tons of beet pulp, with average dry matter content of 20%. A part of that by-product returns to the sugar beet producers, either in the form of strongly hydrated unprocessed mass or as a dried component for animal fodders [Flis et al. 1999, Nowak et al. 1997, Steinhoefel-Saksoński et al. 2001, Guillon et al. 1998]. However, a relatively high percentage of the beet pulp mass does not find buyers and remains at the sugar plants as a noxious and difficult to utilise by-product. Chemical analysis of beet pulp indicates that apart from its utilisation for fodder purposes it may also be a valuable raw material for the food industry, especially for the production of concentrated dietary fibre preparations and pectins [Gruska et al. 2004, Yapo et al. 2007, Hatziantoniou et al. 2002, Kelly 1983].

The components of fibre include non-digestible carbohydrates and their derivatives, such as cellulose, lignins, hemicelluloses and pectins. In the opinion of researchers, the average human diet in the world contains only a half of the necessary amount of dietary fibre [Dobrzycki 1984]. That information indicates a need for a search for products that would contribute to an increase in the consumption of dietary fibre. Literature data show that dietary fibre consumption per day among the population of Poland is only a quarter of that recommended by specialists [Fidel et al. 2000, Hutnan et al. 2000, Arslan et al. 1995]. In the search for a natural and easily available source of fibre that could be utilised in food production without the need for complex processing, an attempt was undertaken to obtain dietary fibre from sugar beet tissue. The used raw material was beet pulp, a by-product at sugar producing plants. Preliminary experiments aimed at obtaining a fibre preparation showed that the preparation was characterised by good water absorption. 100 g of the fibre powder contained ca 80% of fibre composed of 37% of cellulose, 18% of lignins, 20% of pectins and hemicelluloses, and 5% of non-digestible protein [Podgórski et al. 2006, Dobrzycki 1984, Michel et al. 1985, Sakamoto et al. 1995, Dinand et al. 1996, Reddad et al. 2002].

## MATERIAL AND METHODS

The experimental material in the study presented here was beet pulp from the Cukrownia Werbkowice sugar plant, dried to the moisture level of ca 3%.

The dried beet pulp was subjected to disintegration in a hammer mill with a set of three screens, with mesh sizes of 1.5, 2 and 3 mm. The energy consumption and the efficiency of the process of disintegration as related to the applied screen mesh size were measured using a Lumel PP83 type transducer, a PCL 711B card and a PC. That setup permitted electronic recording and saving of the measured instantaneous power consumption. The obtained fragmented dried pump was subjected to determination of physical parameters, such as the angle of slide, angle of repose, bulk density, shaken density, and particle size distribution, in compliance with the relevant standards.

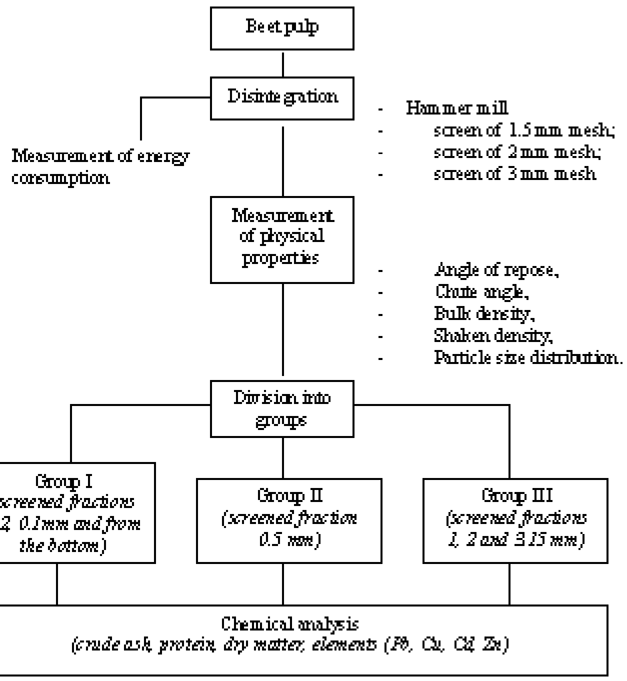


Fig. 1. Scope of examinations of dried beet pulp

The fragmented beet pulp was divided into three groups, as follows:
Group I – all fractions from the screen of: 0.2, 0.1 mm and from the bottom,
Group II –fraction from the screen of 0.5 mm,
Group III –fractions from the screen of: 1, 2 and 3.15 mm.
The division into the groups was made for purposes of identification of chemical composition in the particular size groups.
A schematic of the applied method is given in Fig. 1.

The working hypothesis was that the finest fraction would accumulate the highest level of contaminants. Chemical analysis of the pulp included determination of crude ash, protein as the total content of nitrogen, and elements such as Pb, Cu, Cd, Zn. The chemical determinations were made at the laboratory of the Institute of Sugar Industry in Leszno.

## RESULTS AND DISCUSSION

Table 1 presents the results of measurement of physical properties of dried beet pulp.

Table 1. Physical properties of fragmented dried beet pulp

| Disintegration with screen [mm] | Chute angle [°] | Angle of repose [°] | Bulk density [$kg \cdot m^{-3}$] | Shaken density [$kg \cdot m^{-3}$] |
|---|---|---|---|---|
| 1,5 | 38±1 | 33±1 | 474±2.6 | 540.6±1.96 |
| 2 | 37±1 | 34±1 | 472±3.1 | 530.5±3.2 |
| 3 | 36±1 | 38±1 | 452±2.7 | 508.2±4.84 |

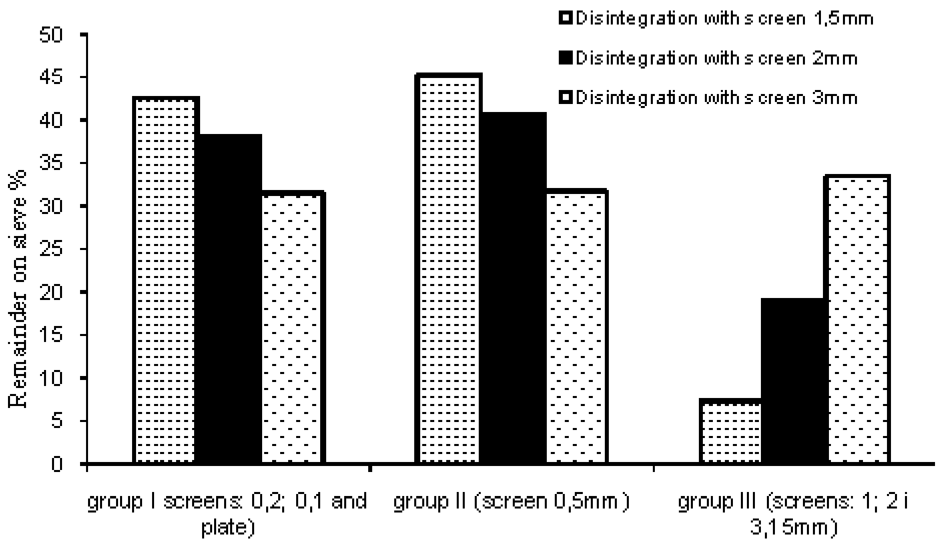


Fig. 2. Fraction composition of fragmented dried beet pulp on the screens as resulting from the degree of disintegration

The physical properties of disintegrated dried beet pulp depend on the degree of disintegration. Disintegration with the hammer mill equipped with a screen of 1.5 mm mesh produced the largest amounts of the fine silt fraction, of 0.2 and 0.1 mm from the screens and on the bottom and 0.5 mm from the screen (ca 45%). Coarse fraction was obtained at the level of only ca 7%. Characteristic results were obtained for the process of disintegration using a screen with 3 mm mesh size. In that case the particle size distribution among the particular size groups was nearly uniform. This was significant for the subsequent chemical analyses and for the measurements of energy consumption in the process of disintegration of dried beet pulp. The assumption for the study was that the particular dried pulp groups would differ from one another, and the sizes of the individual fractions would be an indicator of what part of the pulp is usable for further technological processing. The chute angles and repose of disintegrated dried beet pulp prior to the division into the groups (Tab. 1) did not differ significantly. Significant differences were noted only in he bulk and shaken densities between disintegrated pulp using screens with mesh sizes of 1.5 and 3 mm.

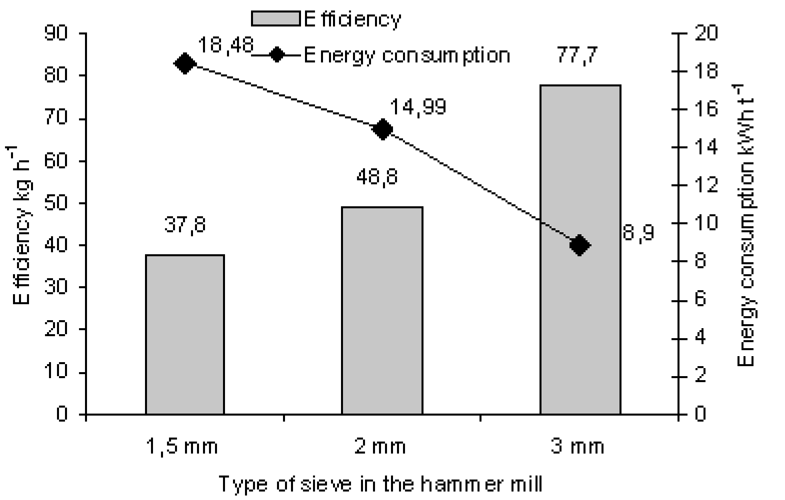


Fig. 3. Energy consumption and process efficiency of dried beet pulp disintegration

The energy requirements of the process of disintegration of dried beet pulp were the highest for the screen with mesh size of 1.5 mm where it amounted to 18.48 kWh t$^{-1}$. With increase in the hammer mill screen mesh size the energy requirements decreased.

Table 2. Chemical composition of fragmented dried beet pulp

| Group | Total ash | Ash insoluble in HCl | Dry matter | Protein as total content of nitrogen | Pb | Cu | Cd | Zn |
|---|---|---|---|---|---|---|---|---|
| | [%] | g·100g s.s.$^{-1}$ | [%] | [%] | ppm | ppm | ppm | ppm |
| I | 16.54 | 12.05 | 98.68 | 8.82 | 7.540 | 13.316 | 0.315 | 19.524 |
| II | 3.91 | 1.01 | 97.78 | 9.63 | 2.257 | 6.146 | 0.395 | 15.812 |
| III | 3.49 | 0.77 | 96.29 | 10.38 | 1.909 | 6.112 | 0.369 | 15.283 |

Group I – highly contaminated with sand

Analysing the chemical composition of fragmented dried beet pulp one can observe that the first group had the highest content of ash (16.54%) and the lowest content of protein (8.82%). Dried beet pulp in group I was highly contaminated with sand and had the highest content of elements (Pb, Cu, Zn). The obtained results may indicate low nutrition applicability of dried beet pulp from the small-mesh screens. Much more valuable was the dried beet pulp from screens with larger mesh sizes, i.e. those in groups I and II. In pulp classified in group III the content of protein was at the level of 10.38%, and total ash content in the samples was within the range of 3.5 – 3.9%. The levels of metallic elements were also lower, nearly 3-fold in the case of lead, and by half in the case of copper and zinc. Only in the case of cadmium the division into fractions had no effect on its content.

## CONCLUSIONS

The results of the study permitted the formulation of the following conclusions:

The hypothesis adopted at the start of the study was proved true, i.e. the finest fraction had the highest content of contaminants and noxious elements. At the same time that fraction had the lowest content of protein and a high level of ash.

The energy requirements of the process of disintegration were the lowest when the hammer mill was equipped with the screen with 3 mm mesh size, when they amounted to 8.9 $kWh \cdot t^{-1}$, which was accompanied by process efficiency that was twice as high as when the screen with 1.5 mm mesh was used.

The use of screens of various mesh sizes permits preliminary separation of contaminants occurring in dried beet pulp from the desirable components.

The most effective was the use of the 3 mm mesh screen on the hammer mill, as in that case the largest amounts of desirable fractions were obtained.

## REFERENCES

Arslan, N. 1995.: Extraction of pectin from sugar-beet pulp and intrinsic viscosity-molecular weight relationship of pectin solutions. Journal of Food Science and Technology, 32, 381–385.

Dea, I. C. M, & Madden, J. K. 1986.: Acetylated pectic polysaccharides of sugar beet. Food Hydrocolloids, 1, 71–88.

Dinand, E., Chanzy, H., & Vignon, M. R. 1996.: Parenchymal cell cellulose from sugar beet pulp: Preparation and properties. Cellulose, 3, 183–188.

Dobrzycki J. 1984.: Chemiczne podstawy technologii cukru. Warszawa. WNT.

Fadel J.G., DePeters E.J., Arosemena A. 2000.: Composition and digestibility of beet pulp with and without molasses and dried using three methods. Animal Feed Science and Technology 85 121-129.

Flis M, Grochowska B. 1999.: Suche wysłodki buraczane – pasza również dla świń. Trzoda Chlewna. R. 37, 8/9.

Gruska R., Wojtczak M. 2004.: Dyfuzja wapnia do tkanki buraków cukrowych. Żywność. Nauka. Technologia. Jakość, 3 (40) Supl., 87-97.

Guillon, F., & Thibault, J-F. 1988.: Further characterization of acid and alkali soluble pectins from sugar beet pulp. Lebensmittel Wissenschaft und Technologie, 21, 198–205.

Hatziantoniou, D., & Howell, J. A. 2002.: Influence of the properties and characteristics of sugar-beet pulp extract on its fouling and rejection behavior during membrane filtration. Desalination, 148, 67–72.

Hutnan M., Drtil M., Mrafkova L., 2000.: Anaerobic biodegradation of sugar beet pulp., Biodegradation, 11, 203.

Kelly, P., 1983. Sugar beet pulp - a review. Anim. Feed Sci. Technol. 8, 1-18.

Michel, F., Thibault, J.-F., Mercier, C., Heitz, F., & Pouillaude, F. 1985.: Extraction and characterization of pectins from sugar beet pulp. Journal of Food Science, 50, 1499–1502.

Nowak W., Brinker S. 1997.: Prasowane wysłodki buraczane: nowa pasza z cukrowni [dla wysokowydajnych krów]. Top Agrar Polska Mag.Now.Rol. 11.

Podgórski W., Gąsiorek E., Leśniak W. 2006.: Produkty uboczne z przerobu buraków cukrowych jako substraty do biosyntezy kwasu cytrynowego. Inżynieria Rolnicza 4

Reddad, Z., Gerente, C., Andres, Y., Ralet, M.-C., Thibault, J.-F., & Le Cloirec, P. 2002.: Ni(II) and Cu(II) binding properties of native and modified sugar beet pulp. Carbohydrate Polymers, 49, 23–31.

Sakamoto, T., & Sakai, T. 1995.: Analysis of structure of sugar-beet pectin by enzymatic methods. Phytochemistry, 39, 821–823.

Steinhoefel-Saksoński O. 2001.: Prasowane wysłodki buraczane: energetyczna pasza dla krów. Top Agrar. Polska Mag.Now.Rol. 10.

Yapo B.M., Robert C., Etienne I., Wathelet B., Paquot M. 2007.: Effect of extraction conditions on the yield, purity and surface properties of sugar beet pulp pectin extracts. Food Chemistry 100 1356–1364.

## CHARAKTERYSTYKA WYBRANYCH PARAMETRÓW FIZYKOCHEMICZNYCH WYSUSZONYCH WYSŁODKÓW BURACZANYCH

**Streszczenie.** W pracy przedstawiono energochłonność oraz wydajność procesu rozdrabniania wysuszonych wysłodków buraczanych oraz określono wybrane właściwości fizyczne i chemiczne otrzymanego produktu. Materiałem badawczym były wysłodki pochodzące z Cukrowni Werbkowice, które były wysuszone do wilgotności ok. 3%. Podczas rozdrabniania w rozdrabniaczu bijakowym z sitem 1,5 mm najwięcej powstawało frakcji drobnej pylistej, z sit 0,2; 0,1 i dna oraz z sita 0,5 mm (ok. 45%). Frakcji grubej powstało zaledwie ok. 7%. Charakterystyczny jest proces rozdrabniania przy użyciu sita 3 mm. W tym przypadku rozkład na poszczególne frakcje jest niemal równomierny. We frakcji najdrobniejszej znajdowało się najwięcej zanieczyszczeń oraz szkodliwych pierwiastków. Jednocześnie frakcja ta zawierała najmniej białka i duże ilości popiołu. Energochłonność procesu rozdrabniania była najniższa przy zastosowaniu sita 3 mm, jednocześnie wzrosła wydajność procesu.

**Słowa kluczowe:** wysłodki buraczane, energochłonność, właściwości fizyczne, analiza chemiczna