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Evaluation of the Threshing Units Type in View of the Quality of Sweet Corn Kernels

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Summary. The objective of this study was to perform a cross-comparison between three various types of thresher units (beater, strip and disc-type) with regard to the grains separation rate and sieve analysis. Before threshing the sweet maize cobs were blanched in water and freezed in liquid nitrogen. The measurements were taken for variable threshing speed. The yield of kernels was determined upon the kernel threshing and the sieve analysis was performed afterwards. It was found out that the type of thresher unit and threshing speed have significant statistical effects on the tested parameters. The highest mean values of the parameters were achieved for the strip-type, and the lowest ones for the disc-type. A rise in the yield of maize kernels was observed as the working speed of the processing unit grew and in line with the share of the grain fraction on sieves with the largest hole-sizes.

Key words: sweet corn, threshing, sieve analyses, separation.

INTRODUCTION

Maize or corn (*Zea mays* L.) is the second largest crop produced in the world [11, 14] and is the third most important cereal in the world after wheat and rice [6, 13]. Sweet corn is one of the most popular vegetables in the USA, Canada, France, Hungary, Australia, India. It is becoming popular in Poland and other European countries. Sweet corn differs from other corns (field maize, pop corn and ornamental) because the kernels have a high sugar content in the milk on early dough stage [12, 15]. It is consumed in the immature stage of the crop. The kernels of sweet corn taste much sweeter than normal corn, namely at 25-30%. The quality and level of sweet corn depends on the type of gene involved for sweetness [7, 13, 16, 19]. Sweet corn for processing is harvested at a relatively immature stage as compared to field corn. Sweet corn for the fresh market is generally harvested by hand or machine at higher moisture content of 70-80% and when the kernels at the top of the cob are 75% fill. Picking may take place over several days as the cobs seldom ripen evenly [10, 21, 22]. Processing of corn is used to increase its shelf life but as a consequence, a significant loss of nutrients may occur via heat degradation or leaching [9, 22]. Kernel quality can be determined using visual evaluation (shape, size etc.) and analytical evaluation (moisture content, bulk density, etc.) as well as physical and mechanical properties [4, 5]. Product quality is a major issue in sweet corn production. High quality sweet corn must be superior in both physical condition and cosmetic appearance. Commercially, the most common method of separating grains of maize from the cob is by cutting the grains with a sharp blade [20]. Unfortunately, in this way it is not possible to obtain whole grains of maize; the cutting operation severs the upper part of the grain from the lower part, which remains on the cob [17, 18]. Thus, the hull of the grain is broken open and part of each grain is wasted including much or all of the germ of the grain. Furthermore, during subsequent wet-processing, including washing and blanching of the severed grains, part of the maize meat is leached from its pouch and lost. Not only is this loss economically detrimental, but significant pollution problem is created. Another, new method for separation of grains from the cob produces the desired intact grains by rapidly freezing the grains on the cob in a liquid cryogenic freezing agent to a depth not exceeding the abscission layer. The frozen cob is then subjected to impact in a conventional field-maize threshing device whereby intact grains are severed from the cob. One advantage of this method is the saving of waste and resulting increased yield of maize. Another is that none of the germ or heart of the grain is lost. Analysis of literature has shown that the research on threshing frozen cobs to produce canned or frozen sweet maize is very scarce. Domin and Kluza [8] performed threshing tests on pop maize with seed moisture of about 15% under temperature of grain between 17.0 and -38°C. However, the threshing of seed maize at 15% moisture level is also possible without freezing cobs. Nkakini et al. [14] reported that threshing is difficult to achieve properly at the moisture content of the grains exceeding 25% (w.b). In case of fresh sweet maize the moisture is above 70%. The objective of this study was to perform a cross-comparison between three various types of thrasher units with regard to the grains separation rate and sieve analysis.

MATERIAL AND METHODS

The cobs of sweet maize of cultivar Garrison were used as the testing material. The cobs for the study were manually harvested from random locations in the plantation during the late-milk ripeness phase. The maize cobs selected for the tests were healthy, straight in shape and had a high degree of grain filling. The characteristic of the test material is shown in Table 1.

Table 1. Characteristic of the test material

Contents	Mean value (SD)
Kernel moisture (%)	76.10 (0 .76)
Weight of cob, (g)	334.3 (21.1)
Length of cob (cm)	23.1 (2.6)
Cob diameter (cm)	4.8 (0.8)
Number of kernels per row, (pcs)	26.0 (1.3)
Number of kernel rows, (pcs)	14.0 (1.5)

The characteristic of the test material was determined by means of tests performed on 100 cobs.

The experimental design is presented in Figure 1.

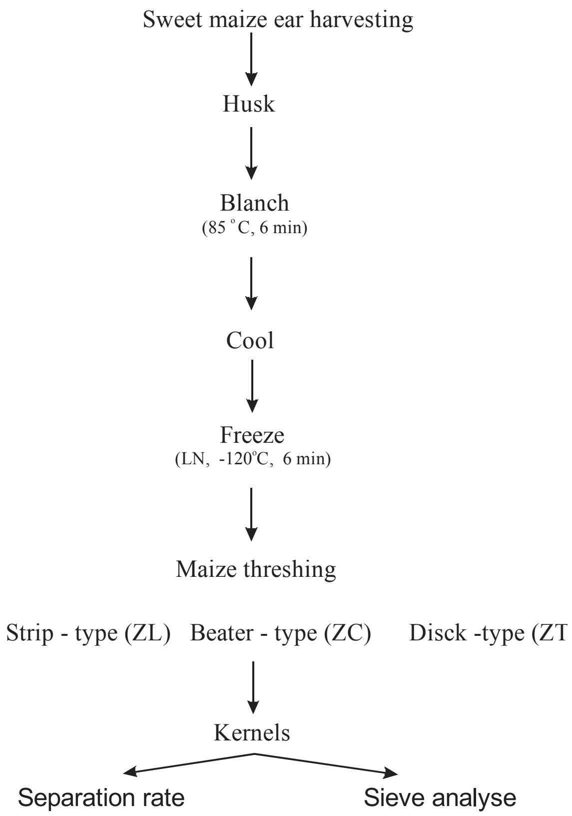

Fig. 1. The chart of experimental design

Moisture of sweet maize kernel was determined by dryer-weighting method. Measurements of the cobs and kernel masses were performed with the use of laboratory scales with 0.1 g reading accurateness; a slide calliper, accurateness of 0.1 mm, was applied for taking measurements of external dimensions of cobs and kernels. Before threshing, the sweet cobs were blanched and frozen. Blanching was carried out in a vessel containing about 15 dm^3 of water, heated by an electrical heater. Each portion containing 10 pieces of sweet maize cobs was placed in a metal basket and submerged in water at 85 °C for 2 min. Then the cobs were chilled out in a cold-water stream to about 20°C and fan-air-dried. The cobs were then frozen in a spraying of liquid nitrogen for 6 min. in the temperature to -120 °C. The cobs were frozen in a special container at which liquid nitrogen was sprayed from the Dewar flask through a special applicator. The threshing was done with three different types of threshing units: classical beater-type (ZC), strip-type (ZL) and disc-type (ZT). The maize thresher was operated with a cylinder (disk) speed from 90 to 130 rad/s for ZL, from 40 to 80 rad/s for ZC and from 70 to 110 rad/s for ZT. The thresher was run empty to stabilize the speed and then 60 maize cobs were fed continuously through the hopper. The grains that had been separated from the cobs were weighed. The remaining grains still attached to the cobs were manually threshed and weighed. All tests were performed on the same date when the maize ears were harvested from the experimental plot. The sieve analysis was conducted for four sizes: m_1 – 8; m_2 – 6; m_3 – 4 and m_4 – 2 mm. The experiments were replicated thrice in 500-gram samples for each threshing speed and the average values were reported.

The kernels separation rate (S_o) was determined according to the following formula:

$$S_o = \frac{W_b - U_z}{W_b} \cdot 100 \ \ [\%], \quad (1)$$

where:
W_b – whole kernel yield [%],
U_z – shelled kernel yield [%].

The whole kernel yield W_b was calculated from the following equation:

$$W_b = \frac{m_k - m_z}{m_k} \cdot 100 \ \ [\%], \quad (2)$$

where:
m_z – mass of kernels removed by hand [g],
m_k – mass of cobs [g].

The shelled kernel yield U_z was calculated using the equation:

$$U_z = \frac{m_c}{m_k} \cdot 100 \ \ [\%], \quad (3)$$

where:
m_c – mass of shelled kernels [g].

Mesh fractions (m_i) and their percentage share (x_i) were determined by the formula:

$$x_i = \frac{m_i}{m} 100 \ \ [\%], \quad (4)$$

where:
m – initial mass of maize grains.

The data were subjected to analysis of variance (ANOVA). Comparison of means was conducted with Tukey's least significant difference (LSD) test, at the significance level p = 0.05.

RESULTS AND DISCUSSION

GRAINS SEPARATION RATE

The tests were carried out on three kinds of maize threshers to determine the mean values of grains separation rate and sieve analysis (see Figures 2, 3 and 4).

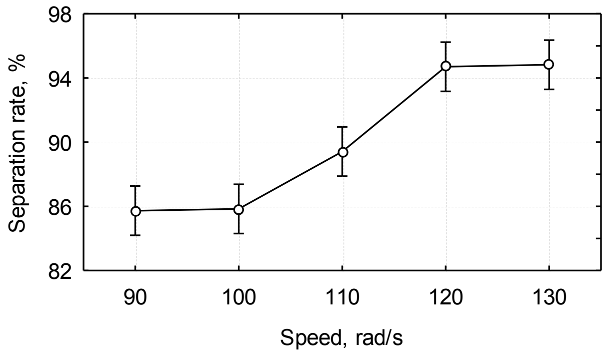

Fig. 2. Mean (with 0.95 confidence interval) grains separation rate for the ZL

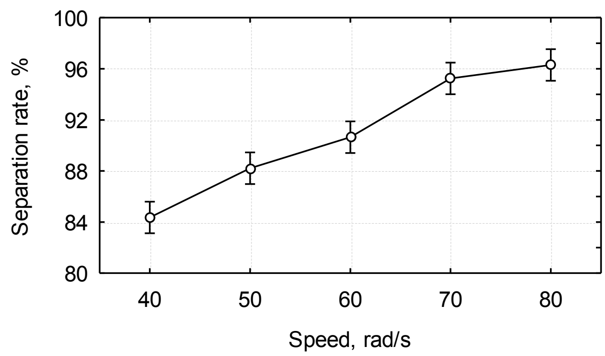

Fig. 3. Mean (with 0.95 confidence interval) grains separation rate for the ZC

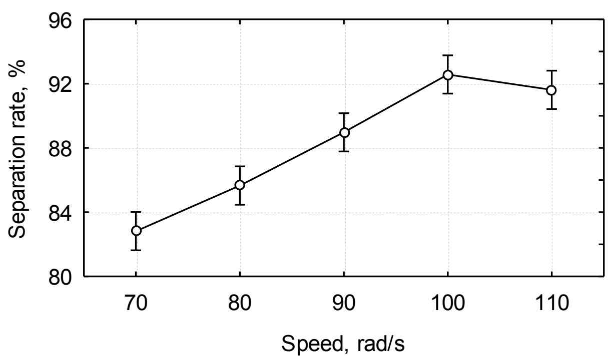

Fig. 4. Mean (with 0.95 confidence interval) grains separation rate for the ZT

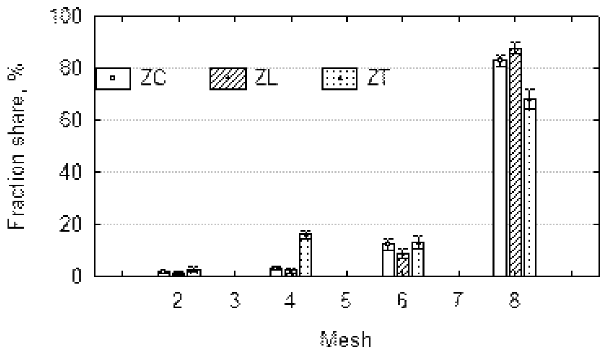

Fig. 5. Fractions share (x_i) in dependence of sieve mesh

Figures 2, 3 and 4 have shown that for a particular thresher unit, the KSR increases along with the increase of threshing speed. The KSR determined as a function of threshing speed ranged from 85.7 to 94.8 % for ZL, from 84.3 to 96.23 % for ZC and from 82.8 to 91.8% for ZT. The results seem to agree with the observation by Domin and Kluza [8]. They found the effects on the decline in threshing losses, depending upon the type of maize variety, between 14.60 and 1.36%, and on the decline in grain damage by 8.21 and 0.86%. The authors showed that the freezing of pop maize had an influence on losses and damage of seeds. Hunt [11] stated that moisture content of maize was probably the single most important crop factor influencing harvesting time and post-harvest operations for maize. Anazodo [2, 3] also reported that grain moisture was a more significant factor influencing the performance of a maize thresher than cob moisture. Alonge and Adegbulugbe [1] reported that the rate of grain breakage increased as the moisture content increased. The sweet maize moisture content appears to be a less significant factor influencing KSR. The authors' own study showed that the time of freezing was a more significant factor influencing KSR. This factor effects hardness of grains.

SIEVE ANALYSIS

The mean values of share of the grain fractions screened on sieves with hole-sizes of 8; 6; 4 and 2 mm ranged from 88 to 1% for the ZL; and from 83 to 2% for the ZC; 68 to 3% for the ZT (Fig. 4).

Fractions share were not significantly different between ZL and ZC. The lowest fractions share occurred on sieve with hole-size of 8 mm for ZT, as a result of working of this kind of thresher unit.

CONCLUSIONS

The following conclusions may be made about the studies of maize threshers:

1. The kind of thresher units is a factor influencing quantity and quality of separating sweet maize grains. A rise in the yield of maize grains was observed as the threshing speed grew and in line with the share of the grain fractions on sieves with the largest hole-sizes.

2. The highest values of separation rate were obtained for beater-type and the lowest for disc-type thresher units.
3. The important implication of the results of this study is that each of the maize threshers can be used for the threshing of frozen sweet maize.

REFERENCES

1. **Alonge A.F., Adegbulugbe T.A. 2000**. Performance evaluation of a locally – developed grain thrasher – II. Journal of Agricultural Mechanization in Asia Africa *and* Latin America, Vol. 31(2), 52-54.
2. **Anazodo U.G.N. 1980.** Mechanical properties of corn cobs. PhD Thesis, McGill University, Montreal, Canada.
3. **Ardelean M., Cordea M., Haş V., Bors A. 2010.** Yield and quality performances of five sweet corn hybrids grown in conventional and organic systems of agriculture. Proceedings of ISHS Congres., Lisbon, 174-178.
4. **Azanza F., Juvik J.A, Klein B..P 1994.** Relationships between sensory quality attributes and kernel chemical composition of fresh-frozen sweet corn. Journal of Food Quality, Vol. 17, 150-172.
5. **Azanza F., Klein B.P., Juvik J.A. 1996**. Sensory characterization of sweet corn lines differing in physical and chemical composition. Journal of Food Science, 61 (1): 253-257.
6. **Cherr C.M., Scholberg J.M.S. McSorley R., Mbuya O.S. 2007.** Growth and yield of sweet corn following green manure in a warm temperate environment on sandy soil. Journal of Agronomy and Crop Science*,* Vol. 193, 1-9.
7. **Chobpattana W. 1994.** Effect of cultivars, maturity and blanching time one quality of frozen whole kernel sweet corn. Dissertation, Kasetsart University, Bangkok, Thailand.
8. **Domin M., Kluza F. 2005.** Decreasing the temperature of popping corn cobs as a process reducing the losses of mechanical seeding. Electronic Journal of Polish Agricultural Universities, Vol. 8, 4.
9. **Falivene S. 1995.** Improving the international competitiveness of the processing sweet corn industry in New South Wales. Final Report HRDC project.
10. **Farahnaky A., Alipour M., Majzoobi M. 2013.** Popping properties of corn grains of two different varieties at different moistures. Journal of Agricultural Science and Technology, Vol. 15(4), 771-780.
11. **Hunt D. 1973.** Farm Power and Machinery Mangement (6 Edn.). Iowa State University Press, IA.
12. **Najeeb S., Sheikh F.A., Ahangar M.A., Teli N.A. 2011.** Popularization of sweet corn (Zea mays L. Saccharata) under temperate conditions to boost the socioeconomic conditions. Maize Genetics Cooperation Newsletter, 85.
13. **Nkakini S.O., Ayotanuno M.J., Maeba G.P.D., Ogaji S.O.T., Robert S.D.** 2007. Manualny-powered continous-flow maize-sheller. Applied Energy, Vol. 84, 1175-1186.
14. **Petkevichiusa S., Shpokasa L., Kutzbach H.D.** 2008. Investigation of the maize ear threshing process. Biosystems Engineering. Vol. 99, 532-539.
15. **Pullar D. 1993.** Winning the race: Being internationally competitive. A case study of the Australian Sweet Corn Industry.
16. **Riad G.S., Brecht J.K. 2001.** Fresh cut sweet corn kernels. Proceeding of the 114th Meeting of the Florida State Horticultural Society, Stuart, Florida, 10-12 June 2001. Proceedings of the Florida State Horticultural Society*,* Vol. 114 (28), 160-163.
17. **Szymanek M. 2008.** Energy consumption at sweet corn threshing. TEKA Komisji Motoryzacji i Enrergetytki Rolnictwa. – OL PAN, vol. 8, 241-247.
18. **Szymanek M. 2008.** Evaluation of quantitative and qualitative losses of the cutting process for sweet corn kernels. Applied Engineering in Agriculture, Vol. 24(5), 559-563.
19. **Szymanek M. 2010.** Evaluation of the disc threshing device in aspect of power consumption and quality of separated maize. TEKA Komisji Motoryzacji i Enrergetytki Rolnictwa – OL PAN, Vol. 10, 446-453.
20. **Waligóra H. 2002**. Sweet corn. Wieś Jutra, Vol. 6(47), 12-16. (in Polish).
21. **Warman P.R, Havard K.A. 1996**. Yield, vitamin and mineral content of four vegetables grown with either composted manure or conventional fertilizer. Journal of Vegetable Crop Production, Vol. 2(1), 13-25.
22. **Warzecha R. 2003.** Sweet taste of sweet corn. Owoce warzywa kwiaty, Vol. 6, 20 -21. (in Polish).

OCENA RODZAJU ZESPOŁU OMŁOTOWEGO W ASPEKCIE JAKOŚCI WYDZIELANEGO ZIARNA KUKURYDZY CUKROWEJ

Streszczenie. Celem pracy było ocena trzech różnych zespołów młócących (listwowy, cepowy, tarczowy) w aspekcie ilości i jakości oddzielanego ziarna od kolb kukurydzy cukrowej. Kolby kukurydzy cukrowej pozyskiwano do badań w fazie dojrzałości przetwórczej (mlecznej). W celu umożliwienia ich omłotu kolby kukurydzy cukrowej poddawano mrożeniu za pomocą ciekłego azotu. Na podstawie uzyskanych wyników oraz analizy wariancji stwierdzono, że rodzaj zespołu młócącego oraz prędkość kątowa zespołu roboczego wywiera istotny statystyczny wpływ na określane wielkości. Wraz ze wzrostem prędkości roboczej zespołu roboczego zaobserwowano wzrost stopnia omłotu kolb oraz udziału frakcji ziarna na sitach o największych rozmiarach otworów.

Słowa kluczowe: kukurydza cukrowa, omłot, analiza sitowa, separacja.