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SEARCH OF METHODS OF LOSES REDUCTION IN PRODUCTION OF SWEET CORN KERNELS FOR PROCESSING PURPOSES

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Summary. The objective of the study was to evaluate sweet corn kernels cutting from the cobs for the processing purposes. The quantity and quality of cut kernels as well as demand for energy cutting was evaluated. Kernels cutting was realized for two research variants: I – cutting with early cobs freezing, II – classical cutting without early cobs freezing. Cobs of kernel moisture of about 76% were frozen in liquid nitrogen for 10 s. Before freezing cobs were blanched in boiling water for 2 minutes and dried. Mesh analysis showed that cutting in variant I was affected by an increase of mesh fractions on the sieves of 6 and 8 mm holes as well as decrease on the sieves of 2 and 4 mm holes. A drop of share of inferior kernels quality and increased demand for energy during cutting were observed.

Key words: sweet corn, freezing, cutting, mesh analysis, demand for energy.

INTRODUCTION

Sweet corn gains most and most popularity in Poland, particularly the food industry shows interest [Waligóra 2006, Warzecha and Nosecka 2007]. This results from numerous factors, and one of the most important is a growing share of Poland in commerce not only in the European market but also worldwide. Along with an introduction of vegetables, commonly consumed in many countries of the world, to our cuisine, there follows a gradual change in our eating habits and out-of-season vegetables are getting increasingly important. A constant growth of sweet corn popularity promotes on one hand the growing of the most effective varieties with the best quality properties and on the other hand the search for optimal cultivation methods and their distribution [Kunicki 2003, 2007].

Sweet corn kernels for consumption are obtained using a special corn cutter, whose work has been described by many authors [Kunjara and Ikeda 1995, Kessler and Harry 1998]. Sweet corn kernels recovery by cutting in food industry is connected with generation of large quantitative and qualitative losses of material [Robertson et al. 1977, Love 1990]. Dependending on a variety and its maturity, only about 70-80% of kernel is removed from the cob in the cutting process. The remaining part of kernels, including a considerable part of germs, is waste [Feibert et al. 1996, Riad and Brecht 2001]. The next operations (rinsing, blanching) cause further mass waste as well as loss of nutritive and alimentary components of kernels [Dougherty 1976, Bundy 1992, Fritz et al. 2001, Mustafa et al. 2004]. The sweet corn waste not only has a negative influence on the economic result, but poses an environmental pollution problem [Robertson and Farkals 1982].

In the paper the hypothesis is assumed that sweet corn losses generated at cutting kernels from the cob can be limited by use of surface freezing procedure before cutting. To explain this hypothesis, this study has attemped at an evaluation of quantity and quality of the cut corn as well as demand for energy at kernel cutting.

MATERIALS AND METHODS

The sweet corn cob of Candle variety was used as research material. The corn cobs were manually harvested in their optimal processing maturity (milk), which was determined on the base of kernels moisture and flesh consistency [Jamieson and Gillespie 1999]. The cobs were randomly taken from different places of the field. The cobs of similar geometrical shape were only classified for tests.

The characteristics of the material are shown in Tab. 1.

Table 1. Characteristics of sweet corn

Contents	Mean value (SD)
Kernels moisture (%)	76.10 (0.76)
Cob mass*(g)	334.3 (21.1)
Cob length (cm)	23.1 (2.6)
Max. 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)

* without cover leaves

The characteristics of the material were determined on the samples of 100 cobs. Kernels moisture was determined according to standard [PN-ISO 6540, 1994]. The mass of cobs and kernels were set by means of laboratory weight WPE 2000p with accuracy of 0.1 g and the linear sizes with caliper with 0.1 mm accuracy.

The studies were carried out for two variants (Fig. 1).

In the IInd variant, otherwise than in the Ist one, sweet corn cobs were blanched and frozen directly before kernel cutting. Blanching was realized in water in dish of 15 dm^3 capacity. Ten cobs were placed in a metal basket and immersed in the boiling water for 2 minutes. Next the cobs were chilled in a jet of cool water (about 5°C), dried and frozen. The sweet corn cobs were frozen in liquid nitrogen steam for 10 s. During this time the whole corn kernels were frozen and got the acceptable hardness for cutting. The blanching and freezing conditions were selected according to preliminary research and literature data [Barrett et al. 2000, Kulvadeee et al. 2002].

The sweet corn cobs were frozen in thermos flask where the nitrogen of Dewar flasks equipped with applicator was supplied.

The kernels cut from the cobs were tested on the laboratory stand consisting of SC-120 Corn Cutter from FMC FoodTech as well as set of electrical energy meters Lumel PP83 [Szymanek et al. 2004]. Measurements were taken at 167.5 $rad \cdot s^{-1}$ angular speeds of the cutter head and at 0.31 $m \cdot s^{-1}$ of linear cob feeder.

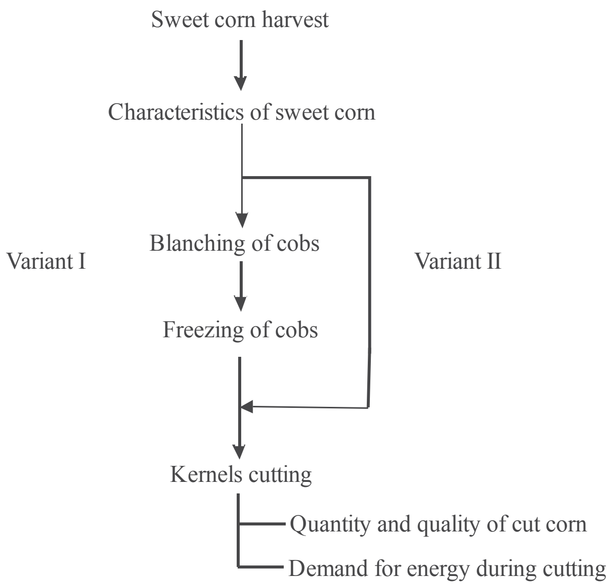

Fig. 1. The scheme of study

The quality of cut kernels was determined by means of mesh analysis and its visualization. Mesh analysis was carried out on the Analysett 3 PRO for 4 sieve set of hole size: m_1 – 8; m_2 – 6; m_3 – 4 and m_4 – 2 mm. The measurement were taken for 300 g samples in 3 replications.

Mesh fractions (m_i) and their percentage share (x_i) with reference to initial mass (m) were determined by the formula:

$$x_i = \frac{m_i}{m} \cdot 100 \quad [\%]. \tag{1}$$

The index of kernel cutting quality was taken at the surface of cut kernel. The quality was recognized as good, when the cross-section was smooth and there were no losses of kernel mass. Every other section was classified as inferior quality. The share of such kernels was calculated using the following formula:

$$U_i = \frac{n_c - n_d}{n_c} \cdot 100 \quad [\%], \tag{2}$$

where:

n_c – number of kernels of good and inferior quality,

n_d – number of kernels of good quality.

Demand for energy during cutting kernels from the sweet corn cobs was calculated on the basis of unit consumption of useful energy at kernels cutting (E_u) [Wojdalski et al. 1998]. The value of energy was the difference of total consumption of energy (E_c) and neutral gear (E_j):

$$E_u = E_c - E_{bj}. \tag{3}$$

An estimation of results was realized on the basis of a one–way variance analysis which made it possible to calculate test function F_o and determine limitary function F_α [Oktaba 1962]. Results were verified with the help of statistical null hypothesis, using its alternative forms:

$F_o > F_\alpha$ – significance influence of factors,
$F_o < F_\alpha$ – lack of influence,
at significance level $\alpha = 0,05$.

Accuracy of particular results was determined by adding values of standard deviations (SD) and 0.95 level of confidence interval for arithmetical mean.

RESULTS

The course of mesh fractions on the particulars sieves in dependence of cutting off variants was illustrated in Fig. 4.

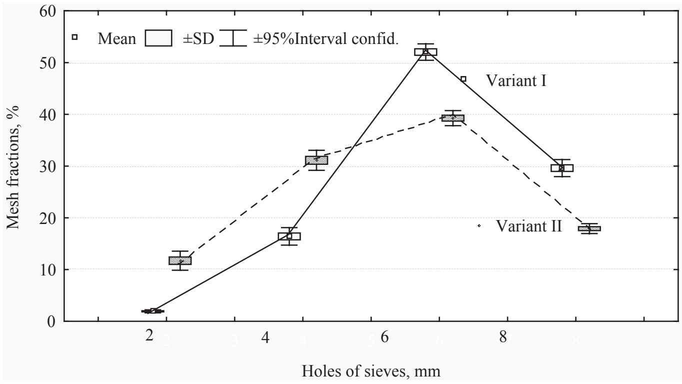

Fig. 4. Mesh fractions in dependence of cutting off kernels variants

Analysis of variance showed, that mesh fractions on the particulars sieves are statistically significantly different between research variants. For cutting kernels without early freezing (variant I) as well as for cutting with early freezing cobs (variant II) the highest percentage share of mesh fractions are obtained on the sieves of 6 mm holes, respectively about 56 and 39% and the lowest on the sieves of 2 mm holes, respectively about 12 and 4%.

Cutting off frozen kernels influenced the growth of its quality (Fig. 5).

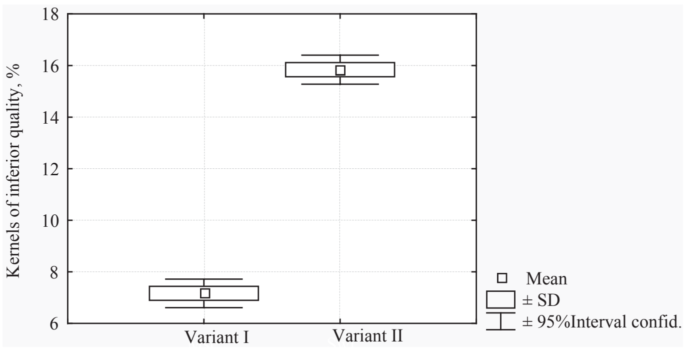

Fig. 5. Share of inferior kernels quality in dependence of cutting variants

Share of inferior kernels quality in variant I amounts to about 7% and in variant II to about 15%. About 50% decline of share of kernels of inferior quality at frozen cobs cutting in relation to cutting without freezing can be interpreted by changes of flesh kernels consistency, from semi-fluent to solid as result of freezing. Such kernels are more susceptible to mass losses during their displacement.

The changes in the courses of useful energy in dependence of research variants illustrated in Fig. 6 showed a higher demand for energy during cutting in variant I than variant II.

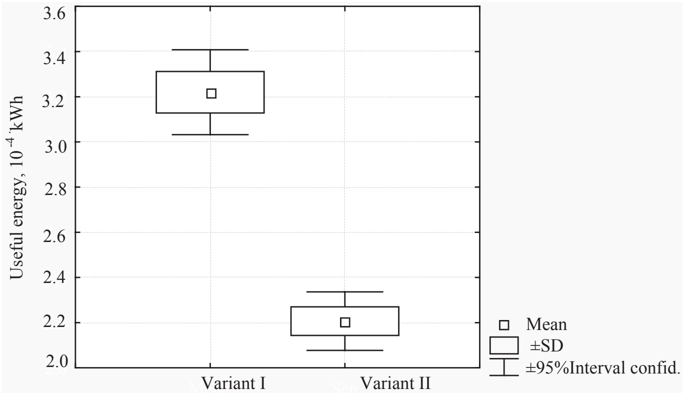

Fig. 6. Useful energy in dependence of variants cutting

Mean values of useful energy in variant I amount to about $2.2 \cdot 10^{-4}$ kWh/cob and in variant II to about $3.2 \cdot 10^{-4}$ kWh/cob. This is an obvious dependence because it results from the growth of resistance during cutting of frozen kernels caused by an increase of kernels toughness.

CONCLUSIONS

1. The tests showed that cutting early sweet corn cobs with freezing, compared to cutting without freezing, influences the growth of quantity and quality of cut kernels. An increase was observed of mesh fractions on the sieves of 6 mm holes by about 46% and on sieves of 8 mm holes by about 28% . There was a decrease on the sieves of 2 mm and 4 mm holes, respectively by 66 and 77%. Share of inferior kernels quality decreased by about 50%.
2. Cutting with early freezing caused, in relation to cutting without early freezing, a decrease of demand for energy during cutting by about 50%.

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POSZUKIWANIE METOD OGRANICZAJĄCYCH STRATY SUROWCA W PRODUKCJI ZIARNA KUKURYDZY CUKROWEJ NA CELE PRZETWÓRCZE

Streszczenie. Celem podjętych badań była ocena procesu odcinania ziarna kukurydzy cukrowej pozyskiwanego na cele przetwórcze na podstawie ilości i jakości odciętego ziarna oraz zapotrzebowania na energię odcinania. Odcinanie realizowano dla dwóch wariantów badawczych: I – odcinanie ziarna poddanego powierzchownemu zamrożeniu, II – odcinanie klasyczne (bez uprzedniego zamrażania). Kolby kukurydzy cukrowej o wilgotności ziarna około 76% poddawano mrożeniu za pomocą ciekłego azotu przez okres 10 s. Mrożenie poprzedzono blanszowaniem w gotującej wodzie przez okres 2 minut oraz osuszaniem. Analiza sitowa wykazała, że odcinanie ziarna według wariantu I wpływa na zwiększenie udziału masy ziarna na sitach o oczkach 6 i 8 mm oraz na zmniejszenie na sitach o oczkach 2 i 4 mm. Ponadto zaobserwowano zmniejszenie udziału ziarna gorszej jakości oraz zwiększenie zapotrzebowania energii odcinania.

Słowa kluczowe: kukurydza cukrowa, mrożenie, odcinanie, jakość, energia.