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INFLUENCE OF SWEET CORN HARVEST DATE ON SWEET CORN KERNEL CUTTING RESISTANCE

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Summary. Sweet corn has a very short period of optimum harvest maturity, and quality changes rapidly near to and following the peak. The objective of this study was to determine the cutting resistance in dependence of date of sweet corn harvest. Sweet corn cobs were harvested 4 times every 2 days. Cutting resistance was determined in dynamics conditions on the specially prepared standing laboratory. Measurements were realized on the 6 cm long pieces of central part of cobs. In the period from the Ist to IVth date of harvest, cutting resistance increased by about 58%.

Key words: sweet corn, kernels, cutting resistance, date of harvest.

INTRODUCTION

Depending on sweet corn's purpose (canned, frozen, fresh market) it is harvested in the milk or late milk stage of maturity ranging from 70 to 78% [Waligóra 2002, Warzecha 2003]. Researches showed that this term lasts a few days but chemical composition is not stable and changes very fast with time [Zawiertajło 1980, Kuminder 1995, Felczyński et al. 1999]. Unsuitable date of harvest can result in the lowering of nutritional and sensory value of kernels as well as an increase of expenditure of energy during cutting kernels from cobs [Wong et al. 1994, Kuminder 1995].

Force resistance at knife movement during cutting process is often determined by means of common parameter of unit cutting resistance. It is defined as force accrued on unit of active length of cutting knife edge [Diakun and Tesmer 1986]. The value of unit cutting resistance depends on the following parameters: geometrical (angle of blade, gradient of blade, radial of blade), kinematical (depth of knife plunge in material, speed of knife edge slide), characterized by the condition of material (temperature, consistency) [Chwiej 1984]. Energy-consuming and resistance occurring during the cutting of kernels off depends on the position of cutting surface [Srivastava et al. 1976, Ajayi and Clarke 1989].

Researches of kernels cutting resistance in quasi-statically conditions were conducted by many authors [Burton 1982, Frontczak 1985, Figiel and Frontczak 2001] and in dynamical conditions [Niedziółka and Szymanek 2004].

The objective of this study was to determine an influence of sweet corn harvest date on cutting resistance during the removal of kernels from the cobs.

MATERIALS AND METHODS

The Candle variety of sweet corn used in the present study was obtained from a crop grown in eastern part of Poland, as representative of commercial processing. When the corn attained the optimum maturity for processing (monitored by moisture content and juice consistency of kernels [Jamieson and Gillespie 1998]), harvest was started. Sweet corn harvesting was continued 4 times every 2 days. At harvest 100 ears were randomly manually picked, husked, sorted, inspected and evaluated for length, maximum diameter and kernels number. Then 30 ears were taken to processing lab and evaluated for kernels moisture and cutting tests. The corn ears selected for study were healthy, of straight shape and high degree of kernel filling.

The linear dimensions of the husked ears were measured using a caliper reading to 0.1 mm.

The moisture content was determined according to standard methods by formula [PN-ISO 6540, 1994]:

$$W = \frac{m_o - m_1}{m_o} \cdot 100 \quad (\%), \tag{1}$$

where:

m_o – mass of kernels before drying (g),

m_1 – mass of kernels after drying (g).

To obtain similar conditions which occurred during sweet corn kernels cutting from the cobs on corn cutter, the cutting force was determined in dynamic conditions. Measurements were realized on the specially prepared laboratory stand (Fig. 1).

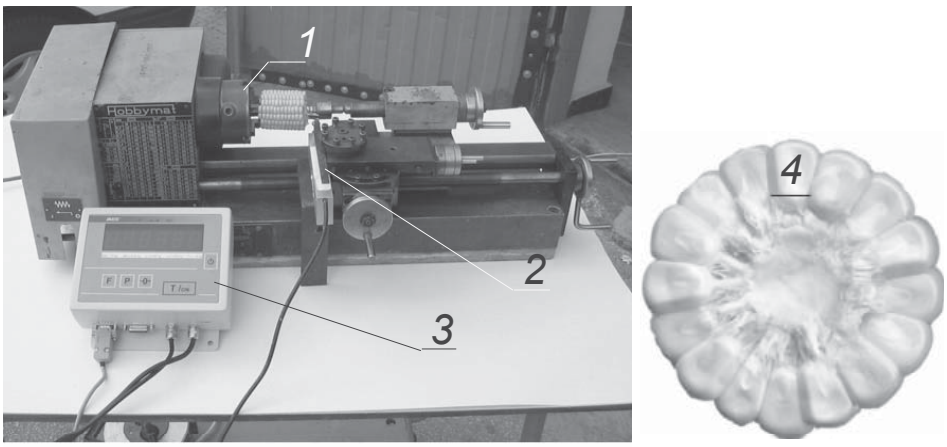

Fig. 1. Laboratory stand: 1– fasten head, 2 – knife with force sensor, 3 – display unit, 4 – place of kernels cutting

Measurements were realized on the 6 cm long pieces of central part of cob. The knife of corn cutting machine SC-120 FMC FoodTech was using in the cutting test.

In Table 1 constructional parameters of knife and working speeds are presented.

Table 1. Parameters of knife and working speeds

No.	Specifications	Value
1.	Angle of blade	8 °
2.	Angle of the edge gradient	15°
3.	Radial of edge rounding	18 mm
4.	Speed of knife head	130.9 rad·s^{-1}
5.	Speed of knife movement	0.010 m·s^{-1}

Cutting resistance was realized for the knife passage for the whole length of samples (6 cm).

Values of cutting resistance were recorded in computer memory with accuracy of 0.1 N and time of sampling of 1 s.

The required number of measurements N was determined on the basis of the number of preliminary measurements n, according to the relation given by Telejka [1999]:

$$N \geq \frac{t_{n,\alpha}^2 \cdot S_x^2}{\delta^2} \quad (szt.), \tag{2}$$

where:

$t_{n,\alpha}$ – critical value of Student distribution t, read for n measurements and significance level of p = 0.05,

S_x – standard deviation,

δ – required level of accuracy.

Data were subjected to analysis of one-way variance and linear regression. Comparison of means was conducted with the Tukey's least significant difference (LSD) test, at a significance level p = 0.05. The results are expressed as mean standard deviation.

RESULTS AND DISCUSSION

Results of sweet corn ear size measured at different harvest dates are presented in Table 2. In the period from the Ist to IVth date of harvest the moisture decreased from 77.41 to 69.83%. A similar decrease of moisture content with an increase of harvest maturity has been reported by Kulvadee and Chowladda [1997], Wong et al. [1994].

Table 2. The mean values of kernels moisture content, yield ears, ear length, ear diameter, number of kernels per row, number of kernel rows with standard deviation in parenthesis

Specifications	Harvest date				LSD p = 0.05
	1st	2nd	3rd	4th	
Moisture content (%)	77.41^{a} (0.95)	75.62^{ba} (0.88)	72.31^{c} (1.05)	69.83^{d} (1.09)	2.05
Length (cm)	22.21(2.09)				-
Max. diameter (cm)	4.94 (0.98)				-
Number of kernels per row (pcs)	28.05 (1.57)				-
Number of kernel rows (pcs)	14.72 (1.54)				-

Numbers in the same line followed by the same letter are not significantly different at p = 0.05.

The graphic display of an influence of harvest date on values of force during the kernels' cutting off cobs is showed in Fig. 2.

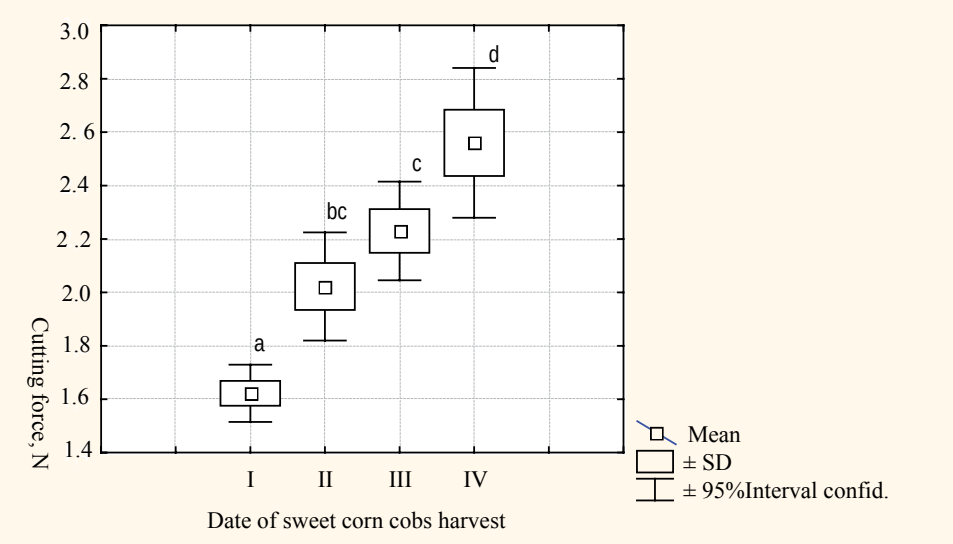

Fig. 2. Cutting force in dependence of harvest date

Table 3 presents results of linear regression for influence harvest date (*T*) on cutting force (*F*).

Table 3. Regressions analysis of *F = f(T)*

Specification	Regression coef-ficient	Standard deviation	Test *t*	significance level p = 0.05
Constans	-32.58	3.21	-10.14	0.0001
T	0.33	0.031	10.81	0.0002

The dependence *F = f(T)* was described by means of statistical model:

F = 0.031T + 0.33 (*r* = 76%)

An analysis of variance showed (Table 3) that regression coefficient and constant are statistically significant at p = 0.05.

The mean value of cutting force ranged from 1.62 N on the Ist harvest date to 2.56 N on the IVth harvest date. An analysis of variance showed that at p = 0.05 the harvest date had an influence on the cutting force. On the basis of Tukey test no significance difference was stated only between the IInd and IIIrd harvest date. (Fig. 2).

A similar dependence was obtained by Burton [1982] on the penetration tests. Michalsky [1986] declares that a decrease of kernels moisture results in maturation and increase of starch making it easy to mechanically cut kernels off the cobs as well as has an influence on reduction of losses. Figel and Frontczak [2001] in quasi-statically conditions conducted research of corn fodder kernels cutting in dependence of knife geometry and kernels moisture. They stated that moisture in form of decrease exponential function has an influence on resistance during kernels cutting.

Researches of Niedziółka nad Szymanek [2004] showed as well the significance of speed of knife feed and angular speed of cob on the sweet corn kernel cutting process.

CONCLUSION

1. Date of sweet corn cobs harvest has a statistical significance influence on values of resistance during kernels cutting offf cobs. In period from the Ist to IVth date of harvest the cutting force increases by about 58%. An increase of cutting force values is followed by a decrease of kernels moisture by about 10% together with the delayed harvest date.

2. The course of an influence of harvest date on cutting force was described by means of linear function.

3. The studies showed that point of harvest date in period of technological usability has a significant influence on cutting kernels off the sweet corn cobs.

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WPŁYW TERMINU ZBIORU KOLB KUKURYDZY CUKROWEJ NA OPÓR ODCINANIA ZIARNA

Streszczenie. Celem pracy było określenie wpływu terminu zbioru kolb kukurydzy cukrowej na wartość oporu odcinania ziarna. Kolby kukurydzy cukrowej pobierano do badań w 4 terminach zbioru, co 2 dni. Opór odcinania ziarna określano w warunkach dynamicznych na specjalnie skonstruowanym stanowisku badawczym. Pomiary realizowano na 6 cm kawałkach wycinanych z centralnych części kolb. W okresie od I do IV terminu zbioru zanotowano spadek wartości oporu odcinania ziarna o około 58%.

Słowa kluczowe: kukurydza cukrowa, ziarno, opór odcinania, termin zbioru.