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ANALYSIS OF EFFICIENCY AND PARTICLES SIZE DISTRIBUTION IN APPLE JUICE OBTAINED WITH DIFFERENT METHODS

Summary

The aim of the study was to investigate the effect of the press construction solution and the size of the sieve hole on the efficiency of the pressing yield and the content of solid particles on the raw juice. In this study two devices, included single- and twin screw press were used. The devices were equipped with two sieves of different hole sizes. Based on the obtained results it was found that the pressing yield and consistency of apple juice depends on the type of press and the size of the holes in the used sieves. In the case of a single-screw press, the change in the size of the sieve holes had no statistically effect on the efficiency of raw juice and the yield of filtered juice. In the case of the twin-screw press a statistically significant effect of sieves size on the yield of pressing was observed.
***Key words**: pressing, screw press, sieve, particles of fruit, apple juice*

ANALIZA WYDAJNOŚCI ORAZ SKŁADU CZĄSTECZKOWEGO SOKU JABŁKOWEGO OTRZYMYWANEGO RÓŻNYMI METODAMI

Streszczenie

W pracy przedstawiono wyniki wpływu rozwiązania konstrukcyjnego prasy oraz wielkości otworów sita na wydajność procesu tłoczenia oraz zawartość cząstek stałych w soku surowym. Do badań wykorzystano dwa urządzenia tj.: jedno – i dwuślimakową prasę wyposażoną w dwa rodzaje sit o zróżnicowanej wielkości otworów. Na podstawie otrzymanych wyników stwierdzono, że wydajność tłoczenia i konsystencja soku jabłkowego zależy od rodzaju zastosowanej prasy i wielkości otworów w użytych sitach. W przypadku prasy jednoślimakowej zmiana wielkości otworów sita nie miała istotnie statystycznego wpływu zarówno na wydajność soku surowego jak i wydajność soku filtrowanego, zaś w przypadku prasy dwuślimakowej zaobserwowano istotny statystycznie wpływ wielkości sit na wydajność tłoczenia.
***Słowa kluczowe**: tłoczenie, prasa ślimakowa, sito, cząstki owoców, sok jabłkowy*

1. Introduction

Apples are one of the most popular fruits used for juice production. Juices obtained from apples are a rich source of vitamins, microelements and biologically active compounds [8]. Nowadays, the consumer market is focused mainly on products with high quality standards. This causes that machine manufacturers modify existing construction solutions for the production of juices with high taste, health and nutritional values [4].

Pressing is the main process in the technology of obtaining fruit juices. During this process, a degree of fragmentation of the material and the amount of pressure applied has a significant impact on the quality of the juice [10]. Also, these factors affect the differences in the chemical composition of the product obtained [2]. The most commonly used devices in the juice industry are basket presses [5] and much less layer presses [1]. The juice can also be obtained by centrifugal forces using decanters [9].

Currently, especially in the household screw presses are becoming increasingly popular [3]. Among them, we can distinguish both single-screw and twin-screw devices.

Single-screw presses are built with one operating element, which transports the material towards the outlet to press through the holes in the sieve. Twin screw presses are built with two rotating in opposite directions screws, which cause intensive grinding and mixing of the processed material. This feature causes, compared to single-screw presses, obtaining juice with a much smaller amount of solid particles [3]. Screw presses are slow-speed devices that, in contrast to juicers, reduce the oxygenation of the juice obtained. This allows to keep a high content of biologically active compounds, and reduce enzymatic browning processes [6]. This process has a significant impact on the quality of the juice obtained. Persic et al. in own studies showed a strongly correlation between the content of polyphenolic compounds and the rate of enzymatic browning [7]. The size of the sieves used is an important issue during the pressing juices on screw presses. Both too small and too large diameter of the holes in the sieve affects the yield of pressing and consistency juice. In the available literature there is no data on the effect of hole size in sieves of screw presses on the process of pressing apple juice. Therefore, the purpose of the work was to determine the effect of the size of the sieves holes.

2. Material and Methods

2.1. The raw material

The research material inclused apples of the Mutsu variety purchased from the Rylex Group. z o.o. from Błędów, 75-80 caliber, manufactured in Poland. Fruit stored in a cold store under controlled conditions of temperature and atmosphere.

2.2. Pressing

The pressing process was carried out using two different devices. In the first case, a single-screw adapter for juicer from Zelmer 986.9000 was used. Two types of different conical sieves with hole dimensions were used, respectively: 1mm for the first sieve (Fig. 1a) and 1.7mm for the second sieve (Fig. 1b).

The second device used was a twin-screw press Green Star Elite 5000 (Tribest) with a power of 260 W (about 110 rpm), equipped with sieves of hole size respectively: 0.4/0.5 for the first sieve (Fig. 2a) and 1.1/1.5 for the second sieve (Fig. 2b).

a)

b)

Source: own work / Źródło: opracowanie własne

Fig. 1. The shape and size of the sieve holes of the single-screw press

Rys. 1. Kształt oraz wielkość otworów sit prasy jednoślimakowej

a) b)

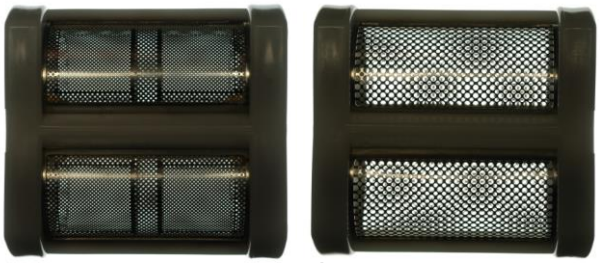

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Fig. 2. The shape and size of the sieve holes of the twin screw press

Rys. 2. Kształt oraz wielkość otworów sit prasy dwuślimakowej

The sieves used differed in the shape and size of the juice flow surface. In the case of conical sieves (Fig. 1), the surface of the juice flow was about 3 times smaller than in the case of twin screw sieves. Additionally, a twin-screw press causes pre-grinding the raw material before pressing.

For each of the devices two types of pressing yield was measured: pressing yield for raw juice (Y_R) and pressing yield for filtered juice (Y_F). These yields were determined based on following equations:

$$Y_R = \frac{m_j}{m_a} \cdot 100\% , \quad (1)$$

$$Y_F = \frac{m_f}{m_a} \cdot 100\% , \quad (2)$$

where:

m_a – mass of apple, m_j – mass of raw juice,

m_f – mass of filtered juice,

Y_R – pressing yield for raw juice,

Y_F – pressing yield of juice after filtration.

After each pressing process the mass content of solid particles in the juice depending on the type of equipment used and sieves was determined.

The filtration process was carried out using a woven polyester mesh with a hole size - 0.25 mm, wire diameter - 0.2 mm, usable clearance - 31 and the number of meshes per cm^{-2} - 493.

Measurements of hole size in sieves were made using the Olympus CX-41 microscope and DP-Soft software at a magnification of 20x.

2.3. Statistical analysis

All the experiments were performed in triplicate independent replications, and the results were expressed as mean value. Statistical analysis was performed using statistical software (Statistica 12, StatSoft Inc., Tulsa, Okla, U.S.A.). Statistical comparisons were made using two way analysis of variance (ANOVA). The significance of differences between mean values was verified by Tukey's test at the significance level $\alpha = 0.05$. Values shown in the graphs with the same letters do not differ statistically significantly ($p < 0.05$).

3. Results

Fig. 3 shows the effect of hole size in the sieve on the pressing yield of apple juices with a single-screw press.

The highest pressing yield for raw juice was obtained for a sieve with a hole size of 1 mm and it was $Y_R = 70.5\%$. The increase in the size of the sieve holes caused a decrease in pressing yield of juice and it was $Y_R = 62.5\%$. In the case of filtered juices, the highest pressing yield was also obtained for sieve 1 with a hole size of 1 mm and it was $Y_R = 49\%$. However, it was found that in the case of the filtered raw juice there were no statistically significant differences in pressing yield depending on the used sieve.

Fig. 4 shows the effect of hole size in the sieve on the pressing yield of apple juices with a twin screw press.

The highest pressing yield for raw juice was obtained for a sieve 2 with a hole size of 1.1/1.5mm and it was $Y_R = 88\%$. The increase in the size of the holes in the sieve has increased pressing yield for the raw juice which is caused by the passage of more solid particles into the juice. For the filtered juice it was observed inverse relationship. The highest pressing yield was obtained for a sieve 1 with a hole size of 0.4/0.5 and it was $Y_F = 69\%$. The increase in the size of the holes in the sieve resulted in a statistically significant reduction in the pressing yield.

In order to better illustrate the influence of the size of sieves on the pressing yield in Fig. 5, the percentage of solids in the obtained juices is shown.

The influence of the size of the holes in the sieves on the solids content in juices was dependent on the type of press used. In the case of single-screw press percentage of solids in the juice obtained ranged from 22 to 27%. There was no statistically significant effect of hole size on the solids content of the apple juices.

For the twin-screw press, the percentage of solids in the juice was dependent on the type of sieve used. For a smaller sieve (hole size 0.4 / 0.5), the average percentage of solids in the juice was about 10%. Increasing the size of the holes in the sieve caused a significant increase in the percentage of solids in the juice and amounted to about 41%. In the case of a twin screw press and a for sieve 2, a high percentage of solid particles resulted in the product consistency more like a puree than a juice.

The equivalent diameter of solid particles in the obtained juices ranged from 9.1 μm to 64.9 μm.

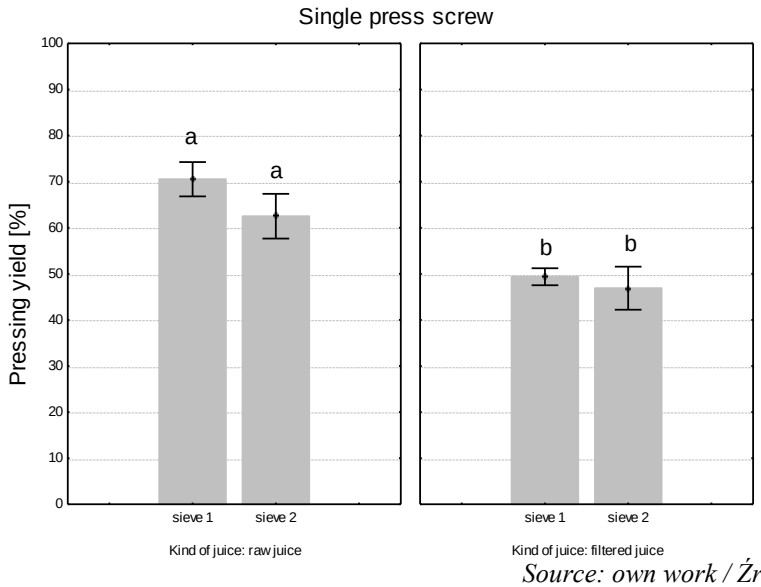

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Fig. 3. The juice efficiency for a single-screw press depending on the sieve used
Rys. 3. Wydajność soku dla prasy jednoślimakowej w zależności od zastosowanego sita

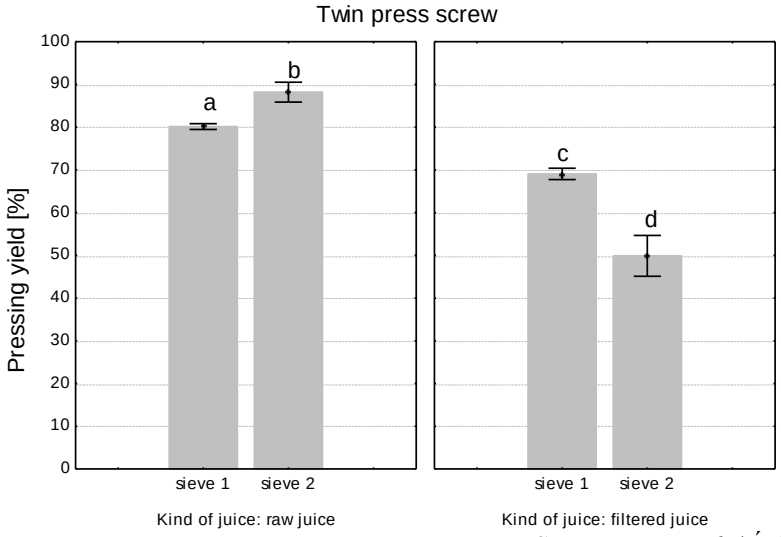

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Fig. 4. The juice efficiency for a twin screw press depending on the sieve used
Rys. 4. Wydajność soku dla prasy dwuślimakowej w zależności od zastosowanego sita

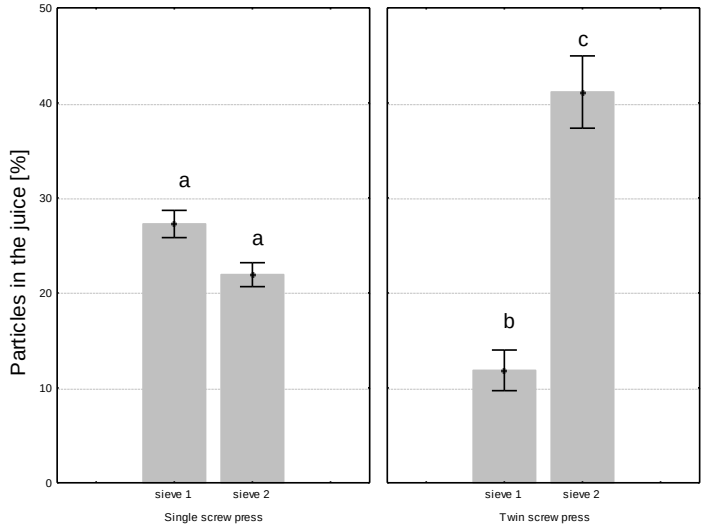

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Fig. 5. The content of solid particles in raw apple juice
Rys. 5. Zawartość cząstek stałych w surowym soku jabłkowym

4. Conclusions

1. The pressing yield and consistency of the apple juice depends on the type of press and the size of the holes in the sieves used.
2. In the case of a single-screw press there was no significant statistical effect of the size of sieve on the pressing yield of raw juice and filtered juice. The consistency of product was similar to cloudy juice in both cases the answer cloudy juice.
3. The change in the size of sieves in the case of a twin screw press resulted in a statistically significant change in the pressing yield for both raw juice and filtered juice. The consistency of product was similar to cloudy juice only in the case of sieve number 1.
4. The twin screw press allows to achieve higher pressing yield than a single-screw press.

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