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The influence of thermal processing on the course of the process of pressing juice from beetroot

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Summary. In this paper the influence was determined of thermal processing on the process of pressing juice from beetroot. The research was conducted with the use of three procedures for yielding juice. The achieved results indicate that utilised thermal processing, which consisted in freezing and pressing, after defrosting the resource, contributes to the increase in the efficiency of the process. At the same time no statistically significant differences in the content of the extract and the pH value of the yielded juice with the use of applied procedures were recorded.

Key words: beetroot, pulp, juice, pressing, freezing.

INTRODUCTION

In recent years the interest in pro-health food with maintained nutrients, which are necessary for a human organism, has increased. An important role in heart diseases prevention is played by fruit and vegetables as well as, achieved from them, juices rich in phitoelements [23]. Thanks to the increased consumption of fruit and vegetables 19% of cases of digestive system neoplasms, 31% of cases of ischaemic heart disease and 11% of cases of infarct could be prevented [11].

Consumers expect food which is minimally processed, which also concerns fruit and vegetables juices. New tendencies in producing fruit and vegetables juices regard the production of the so-called direct juices, naturally cloudy, from ecological and fermented resources [19, 6].

One of the vegetables with proved pro-health properties is beetroot (Beta vulgaris). In Poland beetroot is, except for carrots, the most wide-spread root vegetable in cultivation. An annual consumption of this vegetable in Poland is 12-14 kg per one inhabitant [2].

The root of beetroot contains proteins, sugars, mineral salts, vitamin C and B-group vitamins. It is a dietary vegetable – thanks to the high content of fibre which positively influences digestion processes. Beetroot owes its characteristic colour to the presence of betalain pigments which consist of betacyanins of red colour and betaxantines of yellow colour. Betanin, which has a higher ability to catch radicals than anthocyanins, belongs to betacyanins. Due to strong pro-health properties on the basis of beetroot juice preparations, which constitute a diet supplement, were developed and implemented.

The processing of the resource can significantly change its pro-health properties. The basic method for yielding liquid phase from plant materials is pressing [3, 25, 20, 9]. As research papers indicate, physical processing of juice after pressing (depectinisation, clearing, ultrafiltration and densification) causes the increase of mineral elements [12]. However, the research conducted by Nowak et al. [16] indicates the negative influence of unit operations on pro-health properties of celery and beetroot. Thus, we should seek such methods of processing of the resource which would minimise the negative influence of processing on the pro-health properties. Recently there has been a range of research related to the assessment of the quality of beetroot juice [1, 18], nevertheless, there is little research on the ways of achieving beetroot juice with the lowest quality changes [15].

In the preparation process of the resource for pressing enzymatic processing is utilised, which aims at increasing the efficiency of the process [17]. Lately a tendency to eliminate methods of chemical processing from the production processes can be observed [8]. That is why the interest of researchers has been directed to the utilisation of physical methods of initial pulp processing such as: pulsed electric field processing (PEF), ohmic heating (OH), radiation, sonification, microwave heating, pulp freezing [4, 7, 24, 10, 5, 13]. The use of the abovementioned forms of processing is aimed at preserving organoleptic and nutrition properties at the highest level, at the same time providing the proper level of efficiency.

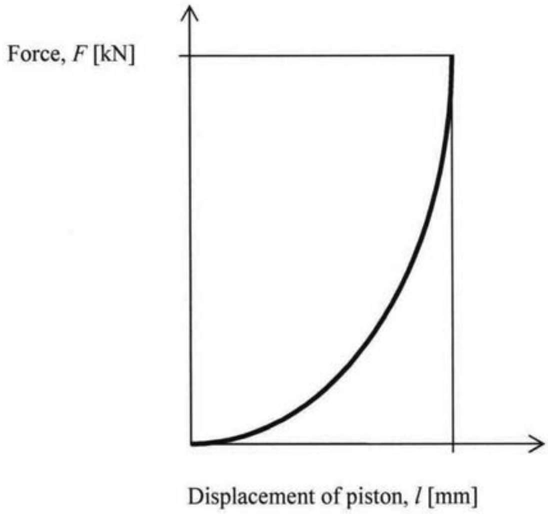

Fig. 1. Example of pressing curve of beet pulp

The aim of this research was to define the influence of the initial processing which consists in freezing and defrosting pulp or marc, on the efficiency and energy consumption of the pressing process. Energy consumption was defined solely in relation to pressing not taking into account energy input related to milling and freezing the resource. The scope of the research included the definition of efficiency and unit energy input of the pressing process and the assessment of the selected quality properties of the yielded juice by identifying the content of extract and juice pH value.

MATERIALS AND METHODS

The research was conducted on roots of beetroot variety Red Ball. It is a variety of high fecundity, for many years recommended for processing and storage [2]. For the purpose of the experiments healthy roots were used, without mechanical damage. Cleaned and peeled resource was milled with the use of milling machine MKJ250 produced by Spomasz Nakło with the use of a standard milling disc with 5 mm perforation. Pressing was conducted in a laboratory self-designed basket press, with the diameter of 80 mm and the capacity of approx. 600 cm^3, which cooperated with Instron 4302 apparatus [14]. Pressing was done with the use of a sieve with ~4 mm perforation and metal mesh. The speed of the piston stroke was defined at 10 $mm \cdot min^{-1}$. Pressing was conducted until the maximum force 9 kN was achieved, then the pressing was stopped. During the first pressing 200 g of vegetable pulp was pressed, whereas during the second pressing it was the marc which was created after the first pressing. The experiment was conducted according to established procedures:

- In procedure I the initial processing prior to the first pressing was milling the resource,
- In procedure II additionally before pressing the marc (second pressing) thermal processing was used, which consisted in freezing the marc in a temperature of -21°C, defrosting and bringing it to the temperature of the surrounding,
- In procedure III thermal processing (freezing and defrosting) of the resource was conducted both prior to the first pressing of pulp and the second pressing of marc.

From the Instron 4302 operating system a relation between the force of piston pressure and its stroke was gained (Fig. 1). After each test the amount of the yielded juice was defined, as well as the content of extract (PN-90/A-75101/02) and pH value (PN-EN 1132:1999) of the yielded juice [21, 23].

Yield of juice was calculated using the following equations:

$$W_j = \frac{M}{Mp},$$

where:

W_j – yield of juice, %,

M – mass of juice after pressing according to established procedure, kg,

M_p – mass of pulp or mass of marc according to established procedure, kg.

Whereas unit energy input was calculated using the following equations:

$$E_j = \frac{W}{M},$$

where:

Ej – unit energy input, $kJ \cdot kg^{-1}$,

W – work of pressing according to established procedure, kJ,

M – mass of juice after pressing according to established procedure, kg.

The conducted research allowed determining energy consumption and the efficiency of the pressing process, as well as defining the basic quality properties of the yielded juice. Statistical analysis of the research results was carried out with the use of ANOVA one-way analysis of variance and Tukey's test.

RESEARCH RESULTS AND THEIR ANALYSIS

Thermal processing of beetroot pulp which consists in its freezing and then defrosting significantly influences the efficiency of pressing (Fig.2). In this case the efficiency of pressing is increased by over 70% (procedure III) in relation to pulp pressed directly after milling. Before the second pressing marc, according to procedure II and procedure III, was frozen and then defrosted before pressing. The efficiency of pressing juice from marc which was not frozen was previously just 5.6%, whereas from frozen marc and defrosted before pressing the efficiency of pressing was at the level of 59.4% (procedure II) and 36.7% (procedure III) (Fig. 3). In this case the efficiency was defined as the mass of juice in relation to the mass of marc after the first pressing. In the next diagram the overall efficiency of pressing for three applied research procedures is presented (Fig. 4). The highest efficiency of pressing was achieved for the process conducted according to procedure III. In this case the efficiency of pressing is higher by 11% in relation to the efficiency which is achieved according to procedure II and by 95% in relation to the efficiency achieved according to procedure III. The analysis of quality parameters of juice expressed by the assessment of juice pH value and the content of extract did not show any significant differences related to the manner of achieving the juice. The content of extract expressed on the Brix scale was from 9.53 to 9.97, whereas pH values of juice were within the range from 5.62 to 5.93 Table 1).

Table 1. Parametry jakościowe soku

Lp.	Procedure	Content of extract [°Brix]	Value pH
1	Procedure I	9,97±0,22a	5,62a±0,14
2	Procedure II	9,78±0,21ab	5,72±0,17a
3	Procedure III	9,53±0,18b	5,93±0,16a

The same letters in columns indicate that non-significant differences were obtained (α = 0,05).

An important parameter for the assessment of the pressing process is its energy consumption. An essential role is played by energy input related to the initial processing of the resource before pressing. In this paper the analysis regarding energy consumption, milling and freeing the resources was omitted. From the analysis of the diagram (Fig. 5) it results that the lowest unit energy input of the first pressing was achieved for the resource which was frozen and defrosted before pressing (procedure III). During the second pressing the lowest values E_{j2} which amounted to 0.25 kJ kg^{-3} were achieved for procedure II, while for marc which was not frozen (procedure I) the value of unit energy input E_{j2} was 3.61 kJ kg^{-3} (Fig. 6). Taking into account both stages of pressing, the lowest value of unit energy input was achieved for procedure II – E_{jc} where the value was 3.61 kJ kg^{-3} (Fig.7).

The process of pressing juice from beetroot executed according to procedure II is characterised by high efficiency and at the same time low energy input as compared to the remaining procedures. However, in the technologi-

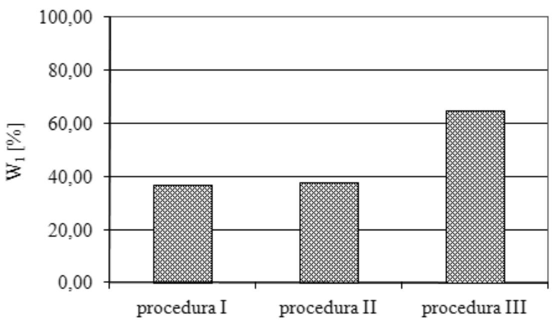

Fig. 2. Yield of juice W_1 during the first pressing in relation to the applied research procedure

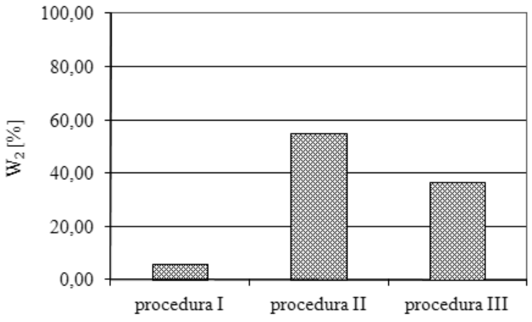

Fig. 3. Yield of juice W_2 during the second pressing in relation to the applied research procedure

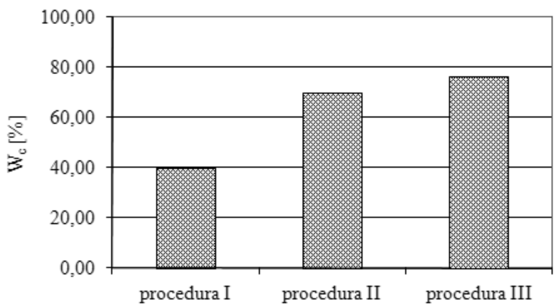

Fig. 4. Overall yield of juice W_c in relation to the applied research procedure

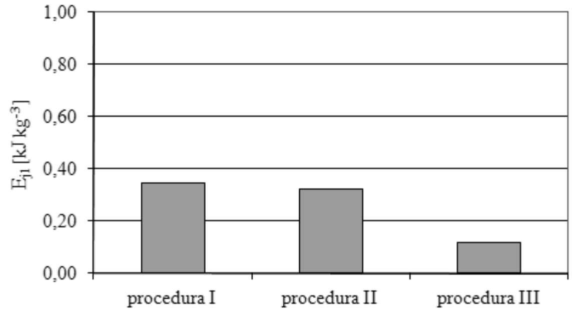

Fig. 5. Unit energy input E_{j1} during the first pressing in relation to the applied research procedure

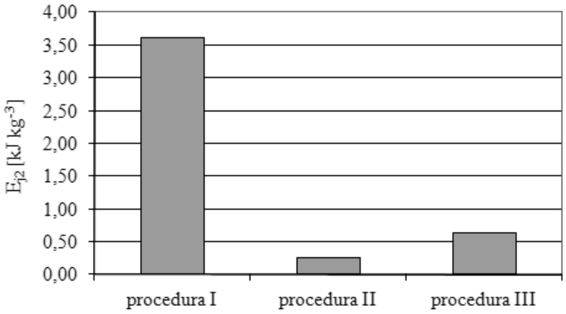

Fig. 6. Unit energy input E_{j2} during the second pressing in relation to the applied research procedure

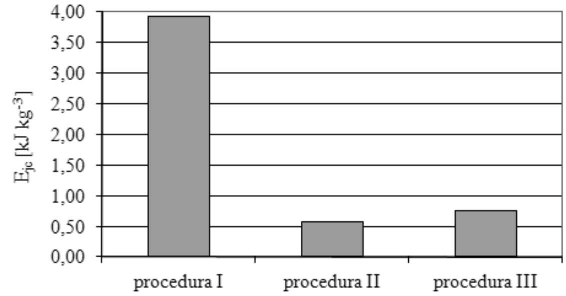

Fig. 7. Summary unit energy input E_{jc} of pressing in relation to the applied research procedure

cal process there exists an energy-consuming process of freezing marc, but taking into account the health aspect, procedure II may be recommended as a method for achieving juices with pro-health properties.

CONCLUSIONS

The conducted research allows for the formulation of the following conclusions:

1. Applied thermal processing increases the yield of beetroot juice. The highest efficiency of the process was achieved by pressing juice according to research procedure III. In this case there occurred a growth of yield by approx. 95% as compared to research procedure I.
2. Summary unit energy input are the lowest for pressing conducted according to research procedures II and III. Energy consumption of pressing beetroot juice drops almost seven times for method II as compared to procedure I.
3. No statistically significant differences in the content of the extract in the achieved juice with the use of different procedures were recorded. Also, no statistically significant differences in the pH value of the juice were recorded.
4. The conducted tests indicate the underlying sense for further research of the influence of the freezing process as the initial processing before pressing, especially having in mind the assessment of pro-health properties of the achieved beetroot juice.

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WPŁYW OBRÓBKI CIEPLNEJ NA PRZEBIEG PROCESU TŁOCZENIA SOKU Z BURAKÓW ĆWIKŁOWYCH

Streszczenie. W pracy określono wpływ obróbki cieplnej na proces tłoczenia soku z buraków ćwikłowych. Badania realizowano z wykorzystaniem trzech procedur pozyskiwania soku. Otrzymane wyniki wskazują, że zastosowana obróbka cieplna polegająca na zamrażaniu i tłoczeniu po rozmrożeniu surowca przyczynia się do zwiększenia wydajności procesu. Równocześnie nie stwierdzono statystycznie istotnych różnic zawartości ekstraktu i wartości pH soku otrzymanego przy pomocy stosowanych procedur.

Słowa kluczowe: burak ćwikłowy, miazga, sok, tłoczenie, zamrażanie.