HEAT CONSUMPTION DURING SELECTIVE PROCESSING OF WHOLE GRAPES FOR RED JUICES

CONSUMUL TERMIC LA PROCESAREA SELECTUVĂ A STRUGURILOR ÎNTREGI PENTRU SUCURI ROȘII

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Abstract.
The processing of grapes of black berry varieties traditionally proceeds according to the in-red method with fermentation on the marc, fully utilizing the phenolic compounds from the solid phase (for red wines).In the case of juices in the absence of the fermentation process, the extraction of biologically active substances (BAS) is problematic. Hygienically valued red juices are almost absent from the market. This study aligns with the series of research projects, and focuses the objective on determining the heat consumption in the selective processing of whole grapes by plasmolysis of the skin, cell destruction and rapid release of anthocyanins, followed by cooling and crushing, separation of the pigmented red juice in the subsequent conservation process. Technical calculations and comparative analysis of thermal consumption and the priorities of applying innovative technology in the production of diet juices in the Republic of Moldova, are presented.
Key words: grapes, juice, innovative technology, calculations, economics.

Rezumat.
Procesarea strugurilor soiurilor cu bace negre decurge tradițional după metoda în-roșu cu fermentația pe boștină, valorificând complet compușii fenolici din faza solidă (vinuri roșii), or în cazul sucurilor în absența procesului fermentativ extracția substanțelor biologic active (SBA) este problematică. Sucurile roșii valoroase igienic aproape că lipsesc pe piață. Acest studiu se aliniază în seria de cercetări și anume, focusează obiectivul determinării consumului termic la procesarea selectivă a strugurilor întregi prin plazmoliza pieliței, destrucția celulară și cedarea rapidă a antocianilor, urmată de răcire și presare, separarea sucului roșu pigmentat în procesul de conservare următor. Sunt prezentate calcule tehnice și analiza consumului termic și prioritățile aplicării tehnologiei progresive în producția de sucuri dietice din R. Moldova.
Cuvinte cheie: struguri, suc, tehnologie inovatoare, calcule, economie.

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INTRODUCTION

The expansion of the areas with red varieties of grapes generates the rise of production. The processing basically proceeds through phase contact during maceration-fermentation on the mark to extract phenolic compounds from the skin of the grapes, which is known to have an antioxidant, anti-radioactive, heart protective effect [Carpov, 1989]. The increase in surfaces, followed by the increase in the volume of the raw material, has also driven to the modernization of the extraction process of biologically active substances (BAS). New innovations such as solid phase agitation, maintenance of the semi-flow regime, used of the roto-vinifier, new-systems under CO_2 equipped with a recirculating system of the must for irrigating the top cap during fermentation. The installations that increase productivity, force the unloading of the container. At the same time, a higher degree of oxidation is observed, along with a loss of aromatic substances and contamination with indigenous microflora [Вакарчук, 1990; Olivieri *et al.*, 1984; Quetsch, 1987].

The technical-economic analysis and the search for a more advantageous processing technology for red grapes, as well as a new product variety, have led us to propose the production of diet red juices using a shortened technology. When heating the skin, thanks to the selective thermal process, ensures the rapid diffusion of pigments, the decontamination of microflora is confirmed and additionally we save energy, and the scheme of the apparatus is abbreviated [Vacarciuc, 2015; Ganea *et al.*, 2010].

First of all, the factors that influence plasmolysis were studied: the temperature, the time of the thermal action, which denote the possibility of diversifying the processing of red grapes in the direction of using at the red juices [Griza and Vacarciuc, 2023**;** Griza *et al.*, 2022]. Thus, the aim of the work is to determine the energy consumption in relation with traditional technologies, having the following objectives: intensifying diffusion, reducing expenses, creating a varied assortment of juices.

MATERIALS AND METHODS

Experiences with various red grape varieties (Alexandrina, Ametist, Negru de Ialoveni, Izabella, Codrinschi) from the "*Codru*" wine region (Botanica, Stăuceni, Ialoveni, Zaicana), harvested at sugar levels between 160-190 g/dm^3 and titratable acidity 8-11 g/dm^3, have allowed to test the juice variants and practically try to call the simplified the technological scheme [Griza *et al.*, 2022]. Grapes of red varieties represent a multi-phase system in which diffusion processes take place due to the penetration of the liquid phase into the capillaries of the solid phase depending on the technological factors: time, temperature, pH and agitation. In the case of the juices production, the following factors are excluded: alcohol, sulfur dioxide, yeast enzymes, etc. (present in wines). The amount of anthocyanins extracted depends on the bio-ecological factors: variety, degree of ripening and the reserve of phenolic compounds in certain microzones.

The short-term selective thermal action (on the skin) on whole grapes (15-20 min./70-80 °C) treated consecutively double: with water and hot juice that ensures cellular plasmolysis with guaranteed release of pigments. It was followed by hydraulic or pneumatic pressing (attenuated), followed by selecting the red must in a volume between 40...50 dal/ton (depending on the variety), which was then directed to clarification and storage. It was used Negru de Ialoveni variety. The grapes were de-stemmed and the crushed must was thermally treated (65 °C, for 2-4 hours), obtaining red juices for conservation and storage. Laboratory analyzes were performed according to standard methods described in the literature.

As a result, the thermo-technological calculations were carried out to determine the energy consumption for whole grapes (per 1 t of processed grapes), in relation to the same mass during the thermo plasmolysis of the crushed must with the heat transfer of the total mass. The thermotechnical calculation was applied according to the methodology - *Processes and separates*, as well as *Technological Equipment in the Food Industry* [Ganea *et al.*, 2010].

$$\mathbf{Q_t = Q_p + G_a + G_{ra} + G_i + G_n}, \qquad (1)$$

The thermal balance is presented – Q_t, in relation to heat consumption (1): t – total; p - product; a -water; ra - radiation; i - installation; n - line losses. Given the presence of the last 4 Gs in both technologies (G_a; G_{ra}; G_i; G_n, the -s are omitted).

Initial dates for the thermal treatment: grapes and must are in relation (2) calculation, from experience grapes - must, m_p - mass of the product, 1000 and 960 kg; specifying the thermal values for the 2 variants: t_1; t_2 (15; 80 °C), at must t_1^*; t_2^* (15, 70) c_p – the specific heat of products: for mustache 4263.82 kg/sec; for grapes 4273.97 kg/sec.

$$\mathbf{Q\,p = G_p\,x\,c_p(t_2 - t_1)} \qquad (2)$$

A comparative thermal calculation of the heating process for the must (M - control) and the grapes (Ex - experimental), using hot water at 90-95 °C was performed. The heat requirement for heating the must or grapes from 15 °C up to 70-80 °C, and the pulp – at 37 °C, that is why the mass was divided into three components: skin (10 %), bunches (4%) and pulp (86 %), respectively: skin 100 kg, bunches 40 kg and pulp 860 kg. In case (M) – the clusters do not participate in the process; the must has an initial temperature of 15^0C, the mass without bunches is uniformly heated to 70 °C. In case (Ex) - thermal treatment of whole grapes, processing of 1000 kg from the temperature of 15 °C (t_2), skin – 100 kg has 80 °C, the bunches - 40 kg reach 60^0C, and the pulp reaches a temperature of 37 °C (t_2^*).

RESULTS AND DISCUSSION

The control variant (same variety, same mass) of grapes - the Negru de Ialoveni grapes were processed by crushing and undergoing a thermal treatment of the must without sulfiting or fermentation. The volume of red juice was experimentally chosen 40 dal per initial ton of grapes, and the pressing was carried out after cooling to 30 °C. In the second case the whole grapes were processed and performed directly in the press tank for heat treatment in laminar - film mode. At the phase boundary the process takes place in 3 phases: heat transfer, mass endo transfers and mechanical diffusion at initial and final determined temperatures.

From table 1, containing the data of the physico-chemical analysis, we observe a higher content of leucoanthocyanins in the experimental samples, compared with the control, but the content is lower of anthocyanins.

The color intensity varies slightly, depending on the degree of maturation and the amount of must used. In contrast, the polymerization index in the experimental juices with limited phase contact was twice lower, they cleared faster and were not subject to phenolic-colloidal disturbances. In terms of quality, the samples of the tasted juices, assessed according to the simple scale of 10 points, the samples had a grade above 8,0 with the aroma of pomace, with a soft balanced taste, which indicates that both juices correspond to the typicality. The temperature analysis in the region of the skin is 70 °C, and in the flesh 37 °C, while in the control 70 °C for the whole meal received. The data according to the content of leucoanthocyanins, phenolic substances and dyes are presented in the table nr. 1

Table 1

Physico-chemical composition and quality of red juice, prepared from the Negru de Ialoveni variety

Physico -chemical indices	BLANK Negru de Ialoveni, 65 °C	Black from Ialoveni 80 °C
Initial temperature, ^{0}C	15	15
Pulp temperature ^{0}C	65	37
Juice temperature ^{0}C	65	37
Mass concentration of:		
- titratable acids, g/dm ^{3}	8.4	8.4
- phenolic substances (F), g/dm ^{3}	0.8	1.3
- leucoanthocyanins (L), mg/dm ^{3}	85.0	180
- anthocyanins (A), mg/dm ^{3}	180.0	170
Color intensity (I), 3mm	0.5	0.7
Key (T)	0.32	0.6
IP* = [(D_{520} -D_{420}) / D_{420}] x 100.% Tasting	150.0	81.0
grade, points, 10	8.0	8.3

*IP – polymerization index

Variant M: 1000 kg of grapes were thermally treated, the must (Q_M) with the initial temperature - (t_1 =15 °C), reaches a temperature of 70 °C in the working room (t_1), and after processing it cools down up to 30 °C (part of the energy is recovered). Next, the heat balance of the grape heating process was determined. Initially, the heat flow given off by the hot agent was calculated:

$$\mathbf{Q_M = G_M / 3600 \times C_M (t_1' - t_1)} \qquad (3)$$

Q_M – the heat flow given off by the hot agent (whistles), W
G_M – mass flow rate, kg/s
C_M – specific heat of combustion, 4263.82 J/(kg·K)
t_1 – the initial temperature of the must, ^{0}C
t_1' – the final temperature of the must, ^{0}C

Thus, according to (3) we calculate:

$Q_M = G_M / 3600 \times C_M (t_1' - t_1) = 960/3600 \times 4263,82 \times 70 - 15 =$ **62536,0 W.sec**

Variant Ex: l a processing of whole grapes 1000 kg, the skin - G_p =100 kg had 80 ^{0} C,

bunches - G_c = 40 kg reached 60 °C, and the pulp - Gpl = 860 kg 37^{0}C, according to (3) we get:

$Q_p = G_p / 3600 \times C_p (t_1' - t_1) = 100 / 3600 \times 4273,97 \times (80 - 15) = 7716,9$ W. sec

$Q_c = G_c / 3600 \times C_c (t_1' - t_1) = 40 / 3600 \times 4273.97 \times (60 - 15) = 2137,0$ W. sec

$Q_{pl} = G_{pl} / 3600 \times C_{pl} (t_1' - t_1) = 100 / 3600 \times 4273.97 \times (37 - 15) = 22462,1$ W. sec

Total Qt = 7716,9 + 2137,0 + 22462,1 = **32316,0 W.sec**

The superimposed calculation of the applied technologies demonstrates the difference in the energy consumed:

$Q = Q_t - Q_m = 62536,0 - 32316,0 =$ **30220,9** W.sec for every 1t of raw material

Taking into account the time consumed, at M = 2 hours (7200 sec), and at Ex = 20 min, and the conversion factor W in kcal, we obtain:

$Q_M = 62536,0 \times 7200 = 45025920$ W x 0,860 = 38722291 kcal

(If 1 Gcal is equivalent to 1 million kcal, then: 38722291/1000000 = **38,723 Gcal**.)

With the new technology:

Qt = 32316,0 x 1200 = 3877900 x 0,860 = 33350112/1000000 = **33,35 Gcal**

The thermal economy is: 38,723 – 33,350 = **5,373 Gcal**, gigocalories per 1 ton of processed grapes.

CONCLUSIONS

From *economic and nutritional* perspectives, it is proposed to diversify the assortment of juices, especially the red ones in the *Codru region, which is characterized by favorable* eco - climatic conditions.

The processing of grapes according to the abbreviated scheme ensures the full extraction of BAS from skin cells, and the diffusion of anthocyanins is in the proportion of 50...60% of the initial content.

The proposed method reduces the energy consumed by 5,373 Gcal, maintains the and significantly decreases the degree of contamination with microflora, although it remains to be specified by how much in future research.

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