

сортів смородини золотистої, а фактор «тривалість стратифікації» мав домінуючий вплив.

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CONTENT AND COMPOSITION OF ORGANIC ACIDS IN STRAWBERRIES (FRAGARIA ANANASSA DUCH.) OF VARIOUS VARIETIES, GROWN IN THE RIGHT-BANK FOREST-STEPPE OF UKRAINE

Аннотация. Ягоды земляники сортов Дукат, Хоней, Полка, Фестивальная ромашка выращенные в Правобережной Лесостепи Украины были исследованы на предмет содержания и соотношения в них органических кислот в спелых ягодах и в процессе созревания. Установлено, что содержание в ягодах земляники органических кислот составляет 0,92 – 1,16 %.

Органические кислоты представлены, в основном, лимонной и яблочной, из них лимонной – 0,7-0,8 %, что составляет 57,1 - 66,7% от общей суммы. Содержание яблочной кислоты установлено на уровне 0,4-0,6%. Активная кислотность ягод установлена на уровне 3,3-3,4 единицы и несущественно отличалась у ягод исследуемых сортов.

Процесс созревания ягод земляники сопровождается постепенным снижением их кислотности, тогда как при перезревании ягод их кислотность снова возрастает за счет увеличения содержания молочной, янтарной и уксусной кислот.

Ключевые слова: земляника, созревание, органические кислоты, лимонная кислота, яблочная кислота.

Introduction. Strawberry is one of the most valuable small berries in Ukraine, which is due to its biological characteristics, curative values and high economic cultivation efficiency. Fresh berries are rich in sugars, organic acids,

vitamins; they have pleasant flavor and balanced taste.

Organic acids play an important role in the formation of berry taste [1-3], their content ranges from 0.21 [4] to 1.3% [5], whereas other authors think – to 2% [6].

Strawberry acidity depends on a variety [7], a region [2, 4, 8], farm practices [9], a harvest date [10], ripening terms [11, 12], maturity extent [13] and other factors.

During ripening some strawberry varieties show acidity increase and at the end of it – some decrease [14], other varieties show gradual acidity decrease during the whole period of ripening [15, 16].

Organic acids in strawberries are mainly citric and malic ones [4, 17, 18]. They affect berry taste, coloration, jelly ability of the fruits and pH of cell sap directly [19]. Also, small amounts of tartaric, oxalic and fumaric acids were found in the berries [20, 21].

The purpose of our research was to determine quantitative and qualitative composition of organic acids during ripening of various strawberry varieties grown in the Right-bank Forest-steppe zone of Ukraine.

Materials and methods.

Experimental work. In 2004-2013 the work was done in the laboratory of the department of the technology of storage and processing of fruits and vegetables at Uman national university of horticulture and at the experimental center of food quality control at the National institute of grape and wine "Magarach". Berries of the varieties Festyvalna romashka, Ducat, Honey, Polka.

Chemical analysis. Qualitative and quantitative composition of acids and sugars was determined using the method of ionic liquid chromatography on the chromatograph of Agilent Technologies (model 1100) [22]. To make the analysis, a carbohydrate chromatographic column (7.8 × 300 mm, "Supelcogel-C610H") was used. Identification of organic acids and sugars was done in accordance with the standard exposure time. Active acidity (pH) was determined by a potentiometer method using a laboratory pH-meter MP 511 (Ulab, Ukraine).

Statistical analysis. Statistic analysis was made using StatSoft STATISTICA 6.1.478 Russian, Enterprise Single User (2007).

Results and discussion.

Qualitative and quantitative composition of organic acids in ripe berries. According to the results received (table 1) organic acid content in strawberries of the varieties studied ranged from 0.92% (variety Festyvalna romashka) to 1.16% (variety Ducat). Minimal content of organic acids in berries was equal to 0.62-1.02%, and maximal one – 0.96-1.4%. It has to be stated that slight acidity fluctuations were observed for Festyvalna romashka berries: 0.89-0.96%. But Polka

and Honey strawberries showed considerable fluctuations – 0.62-1.1 and 0.86-1.2%, correspondingly, which is most likely due to stronger response to weather changes while growing.

It has been proved experimentally that citric and malic acids predominate in the strawberries grown in the Right-bank Forest-steppe zone of Ukraine, while other acids were in small amounts (Table 2, Figure 1). Similar data was received by PELAYO-ZALDÍVAR C. et al. [23]; Zhang J. et al. [14]; Mahmood T. et al. [4].

Citric acid content in berries ranges from 0.7 to 0.8%, which is 57.1-66.7% of the total organic acid content (Figure 2); this corresponds to the data received by Vandendriessche T. et al. [24]. Total content of malic acid is 0.4-0.6%, which is 33.3-42.9%. Ducat berries had its increased content – 0.6%, this indicator for other varieties was lower – 0.4%.

Active acidity of strawberries was at the level of 3.3-3.4 and it differed greatly among varieties.

Qualitative and quantitative composition of organic acids during ripening. The researches proved that strawberry acidity decreased during their ripening, similar data was received by Azodanlou et al. [15]. Thus green berries had the highest acidity – 1.1-1.3%. When berries were becoming red by ½, acidity decreased by 0.1-0.2% and it was equal to 1.0-1.2%. At the stage of marketing ripeness, when berries were red, acidity ranged from 0.7 to 0.9%.

However, when strawberries become red in the stage of gradual senescence their acidity increases slightly again; this is probably due to additional formation of organic acids resulted from fragmentation of polymeric compounds. Our assumptions were proved when qualitative composition of organic acids was studied during ripening up to the stage of fruit senescence on pistillate parent (Table 4, Figure 2).

Thus, green berries have the highest amount of citric acid – 0.9%, but it decreases gradually during ripening and reaches 0.6% at marketing ripeness stage, which is confirmed by the data of Jouquand, C. [10]. Its amount gradually increases and reaches the level of 0.7% when berry coloration changes to dark-red.

Malic acid content at various ripeness stages changes similarly: from 0.16% at a marketing stage to 0.17% in over-ripe berries. The content of lactic and succinic acids in green berries changes from 0.03% to 0.02%, and then it increases gradually again and reaches the level of 0.05%.

Mass share of acetic acid gradually increases during strawberry ripening and it reaches its maximum at an over-

Organic acid content in strawberries (average for the years of 2004-2013)

Table 1

Variety	Organic acid content, %		
	min	max	average
Festyvalna romashka	0,89	0,96	0,92
Ducat	1,02	1,40	1,16
Honey	0,86	1,20	1,02
Polka	0,62	1,10	1,13
LSD 5%	0,02	0,01	0,01

Qualitative and quantitative content of organic acids and pH of strawberries (2012)

Table 2

Variety	Citric acid, %	Malic acid, %	Total content of organic acids, %	pH
Ducat	0,80	0,60	1,40	3,40
Honey	0,80	0,40	1,20	3,40
Polka	0,70	0,40	1,10	3,30
LSD 5%	0,02	0,05	0,01	0,20

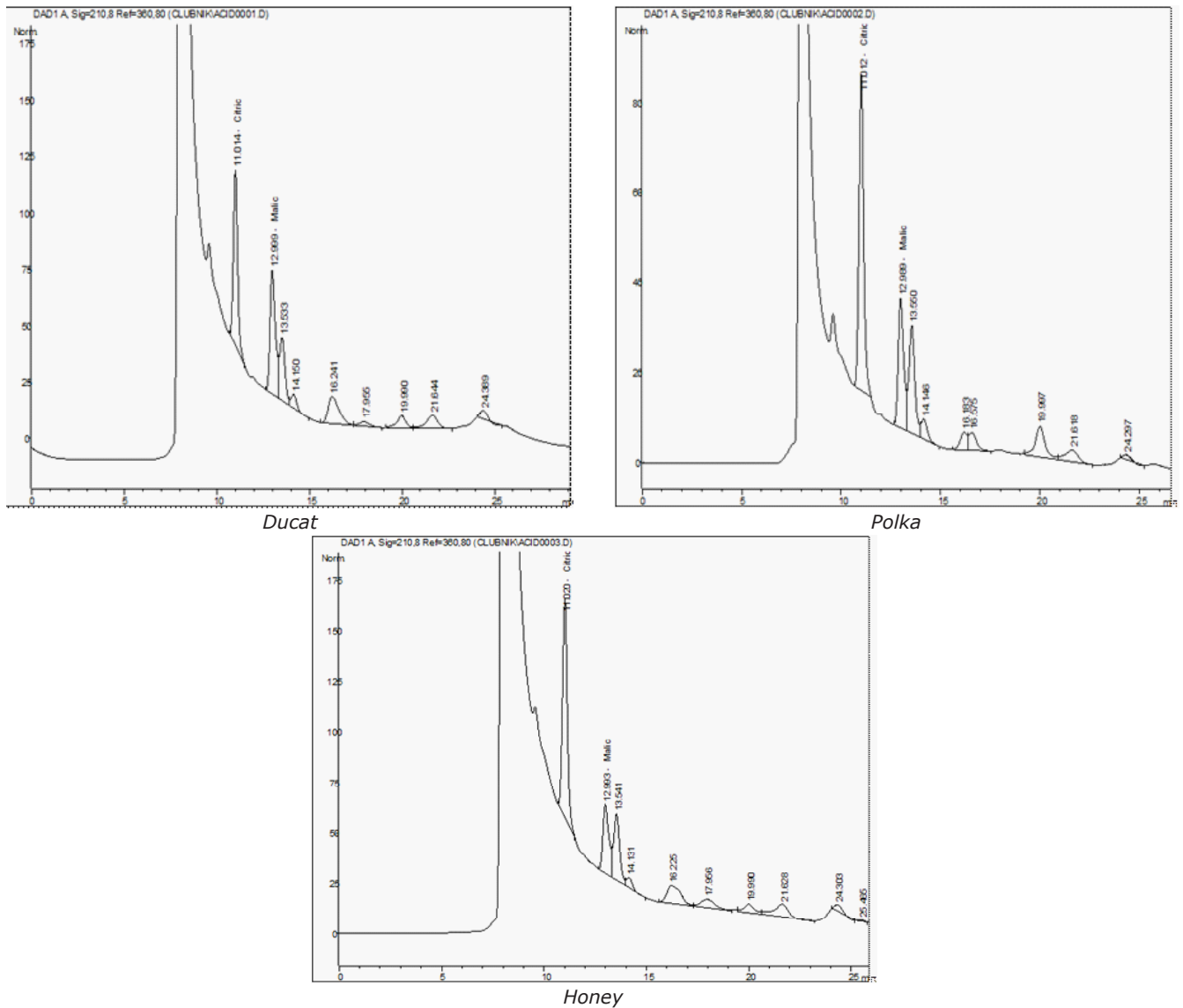


Fig. 1. Organic acid profile of strawberries

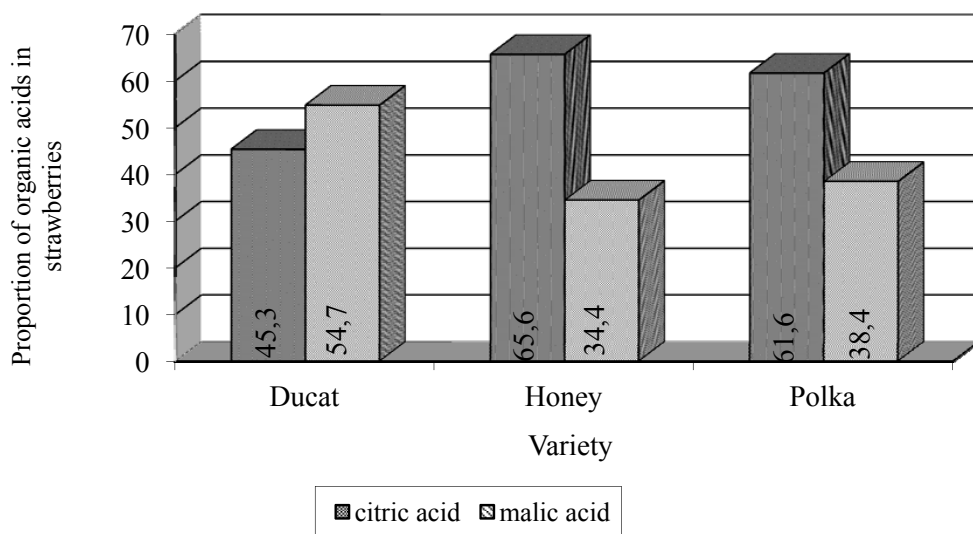


Fig. 2. Quantitative correlation between organic acids in strawberries

ripe stage. It is a known fact that acetic aldehyde increases in ripe strawberries, and ethanol is found in over-ripe berries [25]. It is obvious that acetic acid increase at a marketing ripeness stage of strawberries confirms the enhancement

of anaerobic processes and the formation of under-oxide products: acetic aldehyde and ethanol. The increase of the latter proves the beginning of fermentation.

Thus, total content of organic acids in strawberries

Table 3

Organic acid content in berries depending on their ripeness level (calculated for citric acid), 2013, %

Variety	Ripeness level (by coloration)			
	green	semi-red	red	dark-red
Ducat	1,3	1,1	0,9	1,1
Honey	1,3	1,2	0,7	0,9
Polka	1,1	1,0	0,9	1,0
LSD 5%	0,01	0,02	0,01	0,01

Table 4

Qualitative composition of organic acids in Polka strawberries depending on the ripeness level, % 2013

Berry ripeness level (according to coloration)	Organic acids, %			
	citric	malic	lactic+succinic	acetic
green	0,90	0,19	0,03	0,01
semi-red	0,80	0,12	0,02	0,05
red	0,60	0,16	0,04	0,07
dark-red	0,70	0,17	0,05	0,12
LSD 5%	0,01	0,01	0,01	0,01

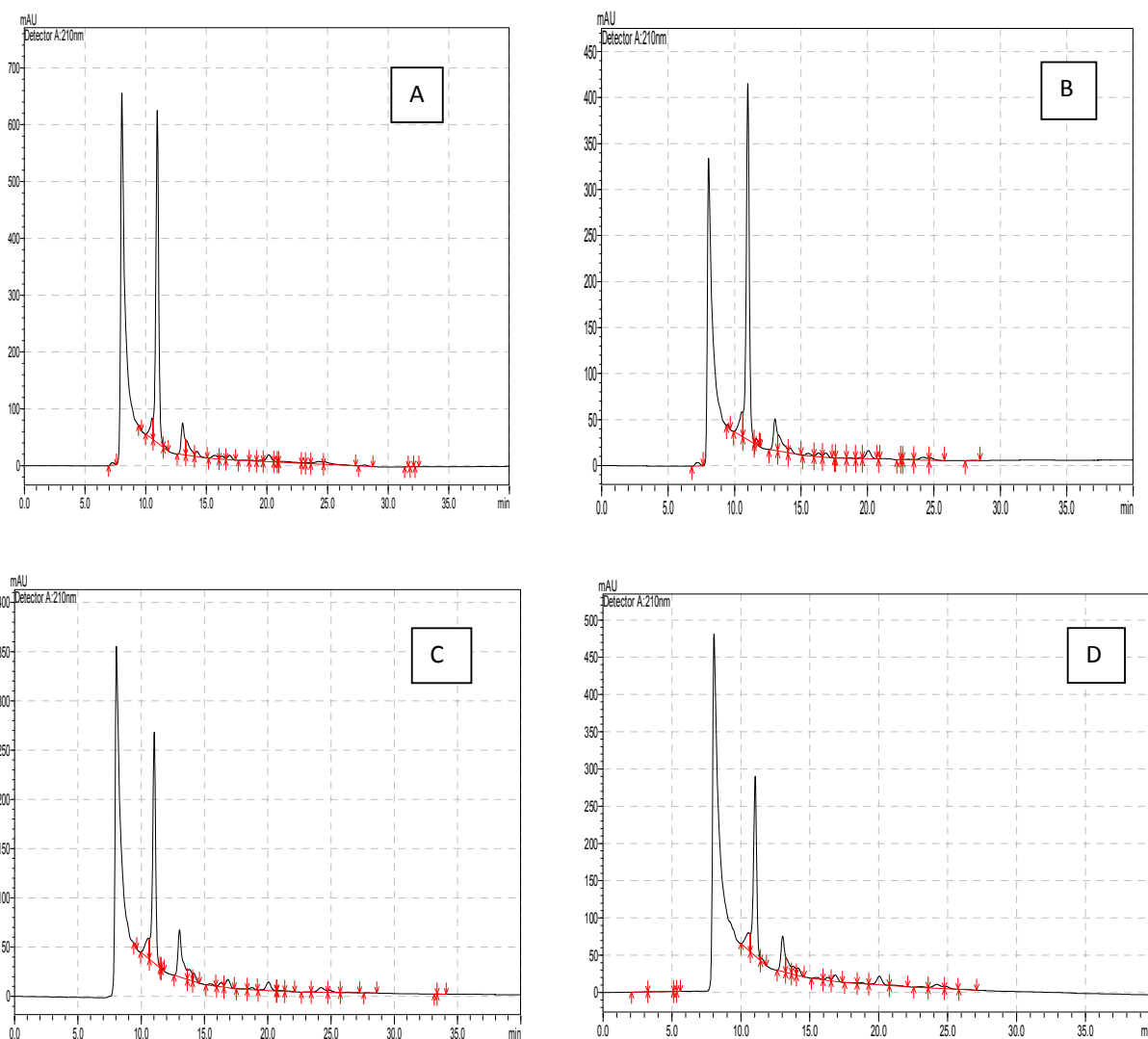


Fig. 3. Organic acid profile in Polka strawberries during ripening: A – green; B – semi-red; C – red; D – dark-red

constitutes 0.92%-1.16%, they are mainly citric and malic acids. The share of citric acid is 57.1-66.7% of the total amount. pH of berries is at the level of 3.3-3.4. During strawberry ripening organic acid content decreases gradually, and during over-ripening it increases again due to the accumulation of lactic, succinic and acetic acids.

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