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ORIGINAL RESEARCH PAPER

INFLUENCE OF GROUND DRY ROSE HIPS (*Rosa canina* L.) ON THE MAIN CHARACTERISTICS OF LACTIC ACID DRINK

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Abstract: The analysis of available literature sources shows that, in most cases, when obtaining enriched lactic acid products, a fixed amount of rose hip supplement was used, and this amount was not specified. Organoleptic analysis is also missing in many of the publications. Further research is needed to establish the optimal amount of ground rosehip (*Rosa canina* L.) fruit in the production of lactic acid products using statistical data analysis methods. As a result of the analyzes carried out in the development, the physico-chemical, organoleptic and color characteristics of a lactic acid drink enriched with coarsely ground rose hips and rose hip flour were determined. The informativeness of these characteristics was established, using appropriate statistical methods for the type of data processed. The appropriate amounts of both additives are defined. For the lactic acid drink obtained with coarsely ground rosehip berries, the optimal amount is 2.76 %, and with the addition of rosehip flour it is 0.53 %. The proposed tools can be used in the development of methods for the valorization of waste products from food production and their addition to dairy products.

Keywords: *color characteristics, fruits, flour, natural ingredients, physico-chemical properties, Rosa canina, sensory quality, yogurt*

INTRODUCTION

The growing attention of consumers regarding health and the role of food in improving the quality of life determine the need to develop new products with improved characteristics that have a beneficial effect on human health [1].

Fortification of conventional foods with bioactive substances is an accepted strategy by scientists, food producers and consumers. Milk and dairy products are among the most important foods used in our daily diet and can be a suitable option for delivering bioactive substances to the human body [2].

Emphasis is placed on the use of harmless, natural additives, increasing the quality and nutritional value of traditional products. High consumption of dairy products and their enrichment can reduce or prevent a number of diseases associated with nutritional deficiencies. Biologically active ingredients, such as probiotic bacteria, polyphenols have a proven beneficial effect on human health [3].

A large body of scientific evidence confirms that the risk of many chronic diseases such as cancer, osteoporosis, cardiovascular diseases, hypertension and others can be reduced through the regular consumption of fermented milk and fermented milk products enriched with functional additives [4].

Fruit juices, different types of fruit flours and extracts have the potential to be used as functional ingredients in the food industry, including in the production of dairy products [5].

In the literature, more and more studies are found regarding different methods of adding functional ingredients to milk and milk products.

Rosehip (*Rosa canina* L.) is a traditional culture for our country, and most of the production is obtained from natural deposits. Rosehip fruits contain organic acids, tannins, pectin and dyes, micro- and macro elements (phosphorus, potassium, magnesium, iron, silicon, manganese, copper). Rosehip fruits are rich in vitamin C and vitamins of group P, B, E, K. With its rich chemical composition, rosehip is a suitable additive in the production of food products intended for functional nutrition.

Küçüköner *et al*. [6], analyzed yogurt with various additives, including rose hips. The authors added 10 % rosehip marmalade to yogurt, and found a decrease in *p*H and an increase in titratable acidity during storage. This also leads to a reduction in the complex organoleptic evaluation.

Turek *et al*. [7], added 3.5 % rosehip seed oil to yogurt. As the reason for the low consumer rating of the fortified yogurt, the authors point to the high percentage of the addition of rosehip oil, regardless of the fact that the fatty acid profile of the product is enriched.

Other authors prove that the addition of 1.5 % rose hip flour in yogurt leads to an improvement in the physicochemical characteristics of the product, increasing its shelf life [8]. The authors did not report the results of an organoleptic analysis.

Kulaitiene *et al*. [9], investigated the influence of different plant additives, including rosehip in amounts of 1 %, in the preparation of milk bites. The authors prove that the added plant additives increase the mineral composition and the total phenolic content of the milk bites. The effect of a higher percentage of additives from plant raw materials on milk bites has not been reported.

Zhelyazkova *et al*. [10], added 5, 10 and 15 % water rose extract to yogurt. The authors found that 5 % of the extract was acceptable to consumers and did not significantly affect the main characteristics of the yogurt. A similar study was done by Alzamara *et al*. [11], who added 5, 10 and 15 % rosehip marmalade to yogurt. The authors recommend adding 10 % rosehip marmalade to yogurt. Taneva et al. [12], analyzed yogurt with increased vitamin C content obtained by aqueous extraction of rose hips at two hydromodule 1:20 and 1:15. The authors recommend extraction at a hydromodule of 1 : 15. A common shortcoming in these studies is that the value of the permissible amount of the additive in the product is not specified.

From the studies and analyses, it can be summarized that in most of the developments, fixed amounts of the additives were used and the optimal amounts were not specified. In most of the publications there is no data on organoleptic analysis.

Further research is needed to establish the optimal amount of added ground rosehip dry fruits and rosehip flour to the production of lactic acid products using statistical data analysis methods. These studies are also the goal of the present work.

The contributions that can be defined in this development are: the physico-chemical, organoleptic and color characteristics of a lactic acid drink with the addition of coarsely ground rose hips and its flour are determined. The informativeness of these characteristics has been established; appropriate statistical methods are chosen, according to the specifics of the processed data; the appropriate amounts of the two additives are defined.

The article is organized in the following order: After a literature review, the purpose and tasks are defined. The methods and instruments used for the analysis of a sour-milk drink with ground and rosehip fruit flour are described. Results are presented for both product types. The optimal amounts of the respective additive have been determined. A comparative analysis was made both between the two types of drinks and with other literary sources. Conclusions are defined and recommendations are made for using the results in practice.

MATERIAL AND METHODS

Used materials

- Raw cow's milk, according to the requirements of EU Regulation 853/2004;
- Sourdough – lyophilized sourdough for butter from the company "Laktina" OOD, Bulgaria with the following composition: *Lactococcus lactis* subsp. *lactis*, *Lactococcus lactis* subsp. *cremoris*, *Streptococcus thermophilus*;
- Dried fruits of the cultivated rosehip variety "Plovdiv-1" from the region of the town of Gotse Delchev, Bulgaria, previously ground to different particle sizes (2-3 mm) and to the appearance of flour.

A comparative analysis of the obtained lactic acid drinks with additions of coarsely ground fruit and rose hip flour was made.

Obtaining the lactic acid drinks

The control and test samples of fermented milk were prepared in laboratory conditions (Department of "Food Technology" at FTT-Yambol, Bulgaria) under the following conditions: cow's milk (3.6 % fat content) was pasteurized at a temperature of 95 °C for 15 min, after which cooled to a temperature of 45 ± 1 ºC and divided into ten batches with different combinations of ground rosehip berries. The amount of rose hips added to the experimental milk samples was 1, 2, 3, and 4 %. Control and experimental milk samples were inoculated with 2 % starter culture in a ratio of 1:5. The milk thus prepared is cut into glass containers and thermostated at a temperature of 44 ± 1 ºC until the milk coagulates. After the end of the thermostating, the fermented milks are cooled to 4 °C and stored at this temperature for 15 days.

Equipment used

- Electrical conductivity (EC, μS/cm), Conductivity Meter AP-2 (HM Digital, Inc., Culver City, CA);
- Active acidity (*p*H), *p*H meter PH-108 (Hangzhou Lohand Biological Co., Ltd);
- Total dissolved solids (TDS, ppm), TDS-3 measuring instrument (HM Digital, Inc., Culver City, CA);
- Oxidation-reduction potential (ORP, mV), Measuring Instrument Model ORP-2069 (Shanghai Longway Optical Instruments Co., Ltd., Shanghai, PR China).

Analysis methods

Active acidity was determined potentiometrically using a *p*H-meter.
The determination of the total (titratable) acidity was carried out by volumetric titration with a standard solution of NaOH (0.1000 N) of substances of an acidic nature in the sample for analysis, in the presence of the indicator phenolphthalein (1 % (w/v) alcoholic solution), until a pale pink color appears, which persists for 1 min (ISO 6091:2010 (IDF 86:2010)).

Color indexes

A Galaxy A53 mobile phone (Samsung Electronics Co., Ltd., Seoul, South Korea) was used to acquire color digital images of rosehip milk-sour drinks. The video sensor is 64 MP.
The resulting color digital images were in the RGB color model. They have been converted to the Lab color model. Color component conversion functions at observer 2º and illumination D65 were used. Color components from RGB (RGB [0 1]) model, converted to Lab (L [0 100], a [-86.18 98.23], b [-107.86 94.47]).
Additionally, the C and h color components of the LCh color model were determined. The color components (C and h) were calculated according to the following formulas:

$$C = \sqrt{a^2 + b^2} \qquad h^o = atan\left(\frac{b}{a}\right) \tag{1}$$

where “a” and “b” are color components from the Lab model.
A total of 16 color indices were obtained for both types of lactic acid drink: L, a, b, C, h, YI, WI, BI, SI, CIRG, COL, CI, ECB, FCI, WL, PACI [13].
The L (Lab) component indicates the level of illumination. It changes from 0-completely dark to 100-light. A (Lab) color component shows the ratio between red and green color, while b (Lab), shows the color changes from blue to yellow. The

component C (LCh) indicates at what distance the center of the color circle is located, and h (LCh) expresses the angle at which the color is located relative to the origin of the coordinate system of the four-color circle. The whiteness index (WI) indicates how white a food product appears to humans. It includes all three components of the Lab model. The yellowness index (YI) indicates how much the color of the product changes from white to yellow. The brown index (BI) is usually affected by the oxidation of phenolic compounds in the product. SI refers to the lightness or darkness of a color compared to white or black. The CIRG index is related to the change in anthocyanin levels in the product. The COL index refers to products containing a carotenoid of the lycopene type. The CI changes depending on the level of carotenoids. ECB shows color changes from yellow to pink. The FCI index serves to simultaneously determine the lightness and the level of yellow in the product. WL shows the ratio between lightness and yellow color level. As an accessible description of this index, one can describe the color of pressed boiled potatoes. PACI shows the level of mixing between red and yellow color.
The presented indices were calculated according to the following formulas:

$$L \quad (2)$$

$$a \quad (3)$$

$$b \quad (4)$$

$$C \quad (5)$$

$$h \quad (6)$$

$$WI = \frac{142{,}86b}{L} \quad (7)$$

$$YI = 100 - \sqrt{(100-L)^2 + a^2 + b^2} \quad (8)$$

$$BI = \frac{x - 0{,}31}{0{,}17} \qquad x = \frac{a + 1{,}75L}{5{,}645L + a - 0{,}012b} \quad (9)$$

$$SI = \sqrt{a^2 + b^2} \quad (10)$$

$$CIRG = \frac{180 - h}{L + C} \quad (11)$$

$$COL = \frac{2000a}{LC} \quad (12)$$

$$CI = \frac{a}{b} \quad (13)$$

$$ECB = \frac{a}{b} + \frac{a}{L} \quad (14)$$

$$FCI = L - b \quad (15)$$

$$WL = \frac{L}{b} \quad (16)$$

$$PACI = \frac{1000a}{L + h} \quad (17)$$

Organoleptic analysis

The organoleptic evaluation of the fermented milk samples was carried out according to a five-point hedonic scale from 1 (extremely dislike) to 5 (extremely like). The main organoleptic indicators on which the organoleptic evaluation was performed were: appearance, color, coagulum, consistency and taste, and aroma.

Selection of informative features

The selection of informative features was done with the ReliefF method. Those characteristics that have weight coefficients with a value greater than 0.6 [14] were selected.

Determining the appropriate amount of additive

A regression model was applied, which was more commonly applied to the analysis of food products. It describes the relationship between two independent and one dependent variable. These coefficients, with $p > \alpha$, have been removed from the model. The model was evaluated by sum of squared errors (SSE), root mean squared error (RMSE) and coefficient of determination (R^2).
To determine the appropriate amount of addition of coarsely ground and rose hip flour in a lactic acid drink, a *linear programming algorithm* implemented by the linprog function was used. An *interior-point-legacy* algorithm was used.
The Matlab 2017b software system (The Mathworks Inc., Natick, MA, USA) was used to process the experimental data. All data were processed at a significance level of $\alpha = 0.05$.

RESULTS AND DISCUSSION

Analysis of a lactic acid drink with coarsely ground rose hips

Figure 1 shows a general view of a lactic acid drink obtained with different percentages of ground rosehip (GRH) addition. Also, the samples are presented in a stylized way, by their averaged color. As the amount of additive increased, the color of the samples changed to darker, and rosette particles were also observed. The change in the appearance and color of the obtained samples which is observed, is probably due to the gradually increasing percentage of the additive (rosehip) and the content of carotenoids and tannins in it.

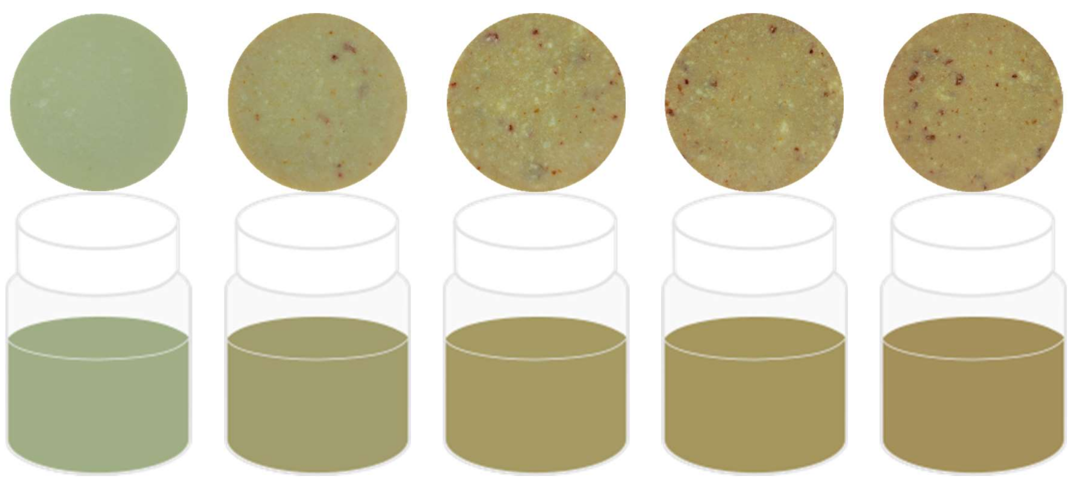

Figure 1. *Lactic acid drink with added grinded rosehip*

Figure 2 shows component data from the Lab model of a coarsely ground rose hip lactic acid drink. It can be seen that the control sample is clearly distinguished from the others with rosehip addition. The data for the spiked samples overlap but are distinguishable from each other. Increasing the amount of additive causes the values of the “L” and “b” components to be maintained, while the “a” component decreases.

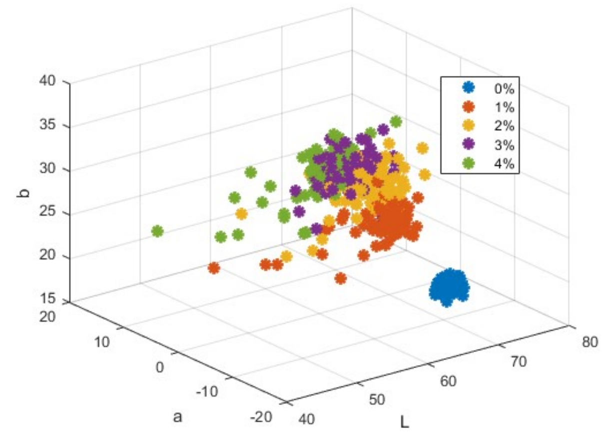

Figure 2. *Lab values of lactic acid drink with grounded rosehip*

Table 1 shows the results of the physico-chemical analysis of a lactic acid drink with the addition of coarsely ground rose hips. From the data on the active acidity values, it can be seen that the samples have an acidic character and it increases proportionally with increasing percentage of rosehip addition. Similar results are observed for the indicator of electrical conductivity, TDS and ORP. These results indicate that increasing the amount of the additive leads to an increase in the acidic character of the lactic acid drink samples. The increased values of the acid nature of the samples are due to the lactic acid fermentation in the milk and the production of lactic acid.

Table 1. *Results from physico-chemical analysis of lactic acid drink with grounded rosehip*

Characteristic \ Additive	0 %	1 %	2 %	3 %	4 %
***p*H**	4.52±0.17	4.37±0.06	4.35±0.12	4.35±0.15	4,35±0.16
TA [ºT]	87±1	65±1	68±2	73±1	79±3
EC [$\mu S\cdot cm^{-1}$]	5640±59	5699±82	5727±96	5952±20	6075±84
TDS [ppm]	223±22	231±3	237±7	215±27	240±20
ORP [mV]	179±21	123±13	176±23	161±33	180±26

All data have statistically significant difference at $p < 0.05$

Table 2 shows the results of an organoleptic analysis of a lactic acid drink with coarsely ground rose hips. By increasing the amount of the additive, the taste and aroma characteristics of the samples are improved. The highest score is obtained for the "taste" indicator, and the lowest for the "consistency" indicator. The general organoleptic evaluation shows an improvement of the product characteristics when increasing the amount of the additive. This is probably due to the denser coagulum, consistency and aroma of the obtained lactic acid drinks, due to the added ground rosehip.

Table 2. *Results from sensory analysis of lactic acid drink with grounded rosehip*

Additive / Characteristic	0 %	1 %	2 %	3 %	4 %
Taste	4.5±0.3	4.5±0	4.5±0.2	5±0	5±0.2
Aroma	4.5±0.4	4.5±0.3	4.5±0.2	5±0.4	5±0.4
Appearance	4±0.1	4±0.5	4.5±0.1	4.5±0.2	4±0.4
Consistency	3±0.5	3±0.1	4±0.1	4.5±0.2	5±0.4
OA	4±0.3	4±0.2	4.4±0.1	4.8±0.2	4.8±0.3

All data have statistically significant difference at $p < 0.05$

Table 3 shows data on the color index values of a lactic acid drink with coarsely ground rose hips. Significant changes are observed in the a (Lab) component, indices YI, COL, CI, ECB, FCI, WL, PACI. For the rest of the color indices, the values are maintained or show minor changes when increasing the amount of additive.

Table 3. *Color indices of lactic acid drink with grounded rosehip*

Additive / Index	0 %	1 %	2 %	3 %	4 %
L	69.39±0.76	64.35±2.46	63.76±2.31	62.36±1.87	60.79±2.92
a	12.08±0.6	6.26±1.62	4.4±1.62	2.72±1.38	1.98±1.72
b	19.58±0.68	26.28±1.92	30.11±2.3	31.7±1.79	31.41±2.46
C	2.73±0.14	4.5±0.25	5.08±0.24	5.38±0.21	5.54±0.2
h	1.02±0.02	1.34±0.06	1.43±0.05	1.49±0.04	1.51±0.06
YI	40.31±1.44	58.34±3.77	67.48±4.77	72.65±4.04	73.77±4
WI	61.7±0.67	55.17±1.75	52.57±1.77	50.65±1.52	49.58±1.73
BI	99.09±9.68	703.34±1322.38	3149.5±11643.69	1171.66±6596.18	185.51±197.32
SI	23.01±0.74	27.06±1.95	30.47±2.34	31.85±1.79	31.53±2.33
CIRG	2.51±0.03	2.64±0.1	2.64±0.09	2.68±0.07	2.73±0.12
COL	127.83±10.84	43.55±11.77	27.13±10.14	16.27±8.35	12.05±11.6
CI	0.62±0.03	0.24±0.06	0.15±0.05	0.09±0.04	0.07±0.07
ECB	0.79±0.04	0.34±0.09	0.21±0.08	0.13±0.07	0.1±0.1
FCI	49.82±0.99	38.08±2.26	33.65±2.53	30.66±2.2	29.38±1.94
WL	3.55±0.13	2.46±0.15	2.13±0.16	1.97±0.11	1.94±0.11
PACI	176.69±8.25	98.72±24.25	69.91±24.69	44.24±21.62	33.66±32.85

All data have statistically significant difference at $p < 0.05$

The selection of informative features is shown in Figure 3. Those features that have weight coefficient values above 0.6 were selected. Two of the physico-chemical parameters, 4 organoleptic characteristics, 3 color characteristics and 8 color indices were selected.

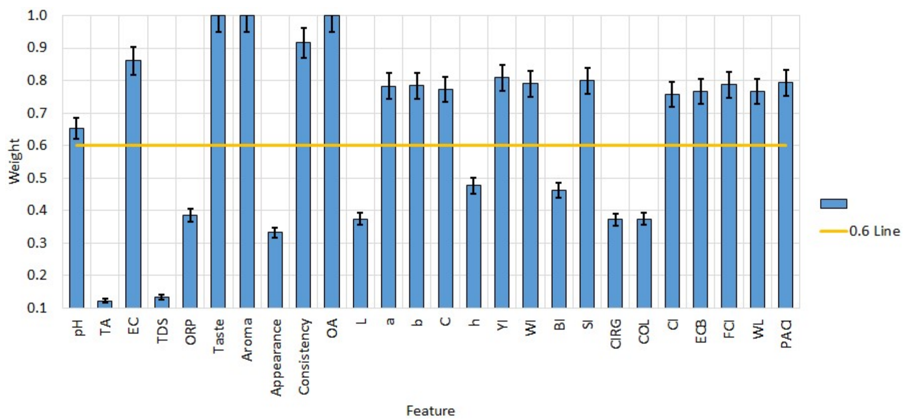

Figure 3. *Feature selection for lactic acid drink with grounded rosehip*
All data have statistically significant difference at $p<0.05$

Selection data are summarized in a vector of 17 characters. The vector has the following form:

FV=[pH EC Taste Aroma Consistency OA a b C YI WI SI CI ECB FCI WL PACI] (18)

The feature vector data is reduced to two principal components. These components describe over 95 % of the source data in the feature vector. A regression model was created, which has a coefficient of determination $R^2 = 0.97$. The sum of squared errors is SSE = 0.23. Root mean square error is RMSE = 0.47. The results show that the obtained model describes the experimental data with sufficient accuracy.
The regression model has the form:

$$GRP = 12.12 + 8.82 \times PC_2 + 1.82 \times PC_1{}^2 - 11.77 \times PC_2{}^2 \quad (19)$$

Figure 4 shows a graph of the appropriate value of the addition of coarsely ground rose hips in a milk-sour drink. The resulting appropriate value of the amount of ground rosehip is plotted. A suitable amount of 2.76 % of the coarsely ground rose hip additive in a lactic acid drink was determined. This amount is acceptable to consumers and does not significantly change the physico-chemical, organoleptic and color characteristics of the product.

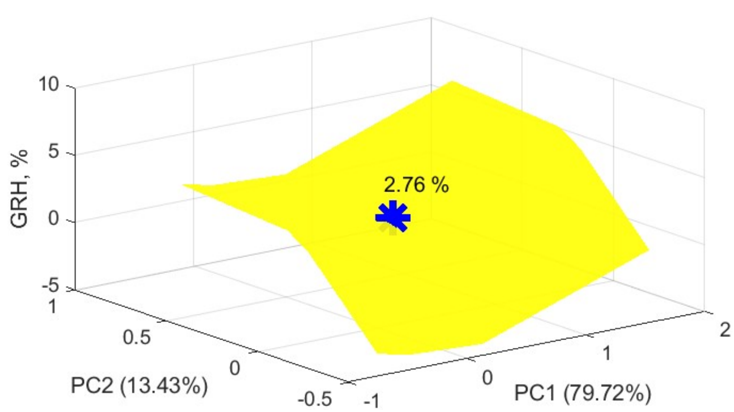

Figure 4. *Determining the appropriate amount grounded rosehip in lactic acid drink*

Analysis of a lactic acid drink with the addition of rose hip flour

Figure 5 shows a general view of a lactic acid drink with rose hip flour (RHF). The samples are presented in a stylized form, by their averaged color. As the amount of additive increases, the color of the samples changes to darker. Finely milled rose hip flour results in a denser color of the milk-sour drink compared to ground rosehip samples.

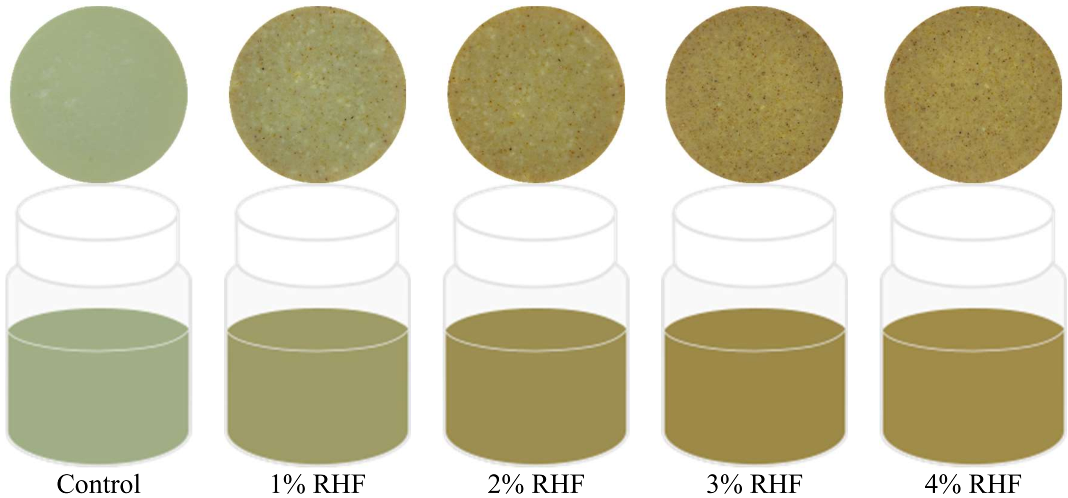

Figure 5. *Lactic acid drink with added rosehip flour*

Figure 6 shows component data from the Lab model of a lactic acid drink with rose hip flour. It can be seen that the control sample and those with the addition of 1 and 2 % rose hip flour are clearly distinguished from the other samples. The data for the 3 and 4 % additive samples overlap but are distinguishable from each other. Increasing the amount of additive causes the values of the "L" components to remain the same, while the "a" component decreases and the "b" component increases.

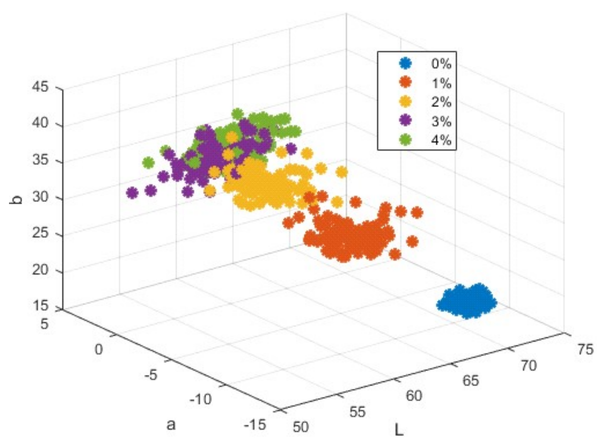

Figure 6. *Lab values of lactic acid drink with rosehip flour*

Table 4 shows the results of a physico-chemical analysis of a lactic acid drink with rose hip flour. Measured values of active acidity were as low as 4.18 to 4.52, and as the amount of additive increased, the *p*H decreased proportionally. The titratable acidity decreased from 87 to 67 ºT in the 2 % addition sample, then increased slightly. Electrical conductivity, TDS and ORP also increase as the amount of additive increases. These results indicate that increasing the amount of the additive leads to an increase in the acidic nature of the lactic acid drink samples. The reason for the increase in the acidity of the lactic acid drinks with the addition of rose hip flour is similar to that of the lactic acid drinks with the addition of coarsely ground rose hip.

Table 4. *Results from physico-chemical analysis of lactic acid drink with rosehip flour*

Additive / Characteristic	0 %	1 %	2 %	3 %	4 %
***p*H**	4.52±0.17	4.3±0.13	4.18±0.09	4.24±0.07	4.42±0.09
TA [ºT]	87±1	73±3	67.33±4.51	68.33±4.51	78±2
EC [$\mu S \cdot cm^{-1}$]	5640±59	5921±49	6009±37	6009±14	5892±26
TDS [ppm]	223±22	245±3	248±2	250±2	245±8
ORP [mV]	179±21	260±74	292±84	279±46	224±41

All data have statistically significant difference at $p < 0.05$

Table 5 shows the results of an organoleptic analysis of a milk-sour drink with rose hip flour. Increasing the amount of rosehip flour leads to a deterioration in the taste and appearance of the product. The aroma, consistency and appearance are improved. The overall assessment shows that increasing the amount of rosehip flour leads to a deterioration of the organoleptic characteristics of the lactic acid product. The deteriorated organoleptic evaluation for taste and appearance is probably due to the incomplete dissolution of some of the rosehip components.

Table 5. *Results from sensory analysis of lactic acid drink with rosehip flour*

Additive / Characteristic	0 %	1 %	2 %	3 %	4 %
Taste	4.5±0.3	4±0.4	3.8±0.1	2.5±0.1	1±0.4
Aroma	4.5±0.3	4.5±0	4.6±0.2	4.7±0	5±0.4
Appearance	4±0.4	4±0.3	4.1±0.2	4.2±0.1	4.5±0.4
Consistency	3±0.4	3±0.1	2.8±0	3.3±0.1	4±0
OA	4±0.4	3.9±0.2	3.8±0.1	3.7±0.1	3.6±0.3

All data have statistically significant difference at $p < 0.05$

Table 6 shows data on the color index values of a milk-sour drink with rose hip flour. Significant changes are observed in a and b (Lab), C (LCh) components, indices YI, SI, COL, CI, ECB, WL, PACI. For the rest of the color indices, the values are maintained or show minor changes when increasing the amount of additive.

Table 6. *Color indices of lactic acid drink with rosehip flour*

Additive / Index	0 %	1 %	2 %	3 %	4 %
L	69.55±0.7	63.42±1.53	59.32±1.51	57.94±1.65	59.08±1.61
a	12.2±0.5	7.46±0.83	4.21±0.86	1.55±0.86	1.38±0.81
b	19.66±0.69	28.11±1.69	34.52±1.63	36.96±1.86	38.08±1.66
C	2.73±0.14	4.54±0.22	5.5±0.19	5.96±0.14	6.06±0.12
h	1.02±0.02	1.31±0.03	1.45±0.03	1.53±0.02	1.53±0.02
YI	40.38±1.47	63.38±4.37	83.21±4.83	91.13±3.47	92.08±3.16
WI	61.75±0.67	53.23±1.63	46.45±1.66	43.93±1.01	44.04±1.01
BI	97.3±7.76	541.3±1567.59	4152.93±25522.8	169.16±56.86	163.59±49.22
SI	23.14±0.68	29.1±1.62	34.79±1.59	37.01±1.88	38.11±1.67
CIRG	2.5±0.02	2.67±0.06	2.8±0.06	2.84±0.07	2.79±0.07
COL	129.01±10.17	51.96±6.47	25.86±5.38	8.91±4.8	7.63±4.39
CI	0.62±0.03	0.27±0.03	0.12±0.03	0.04±0.02	0.04±0.02
ECB	0.8±0.04	0.38±0.05	0.19±0.04	0.07±0.04	0.06±0.03
FCI	49.89±0.98	35.3±2.47	24.8±2.44	20.97±1.46	21±1.43
WL	3.54±0.13	2.26±0.15	1.72±0.1	1.57±0.06	1.55±0.05
PACI	177.95±7.13	119.89±11.51	72.55±13.55	27.14±14.57	23.64±13.55

All data have statistically significant difference at $p < 0.05$

The selection of informative features is shown in Figure 7. Those features that have weight coefficient values above 0.6 were selected. 2 of the physico-chemical indicators, 4 organoleptic characteristics, 4 color characteristics and 8 color indices were selected.

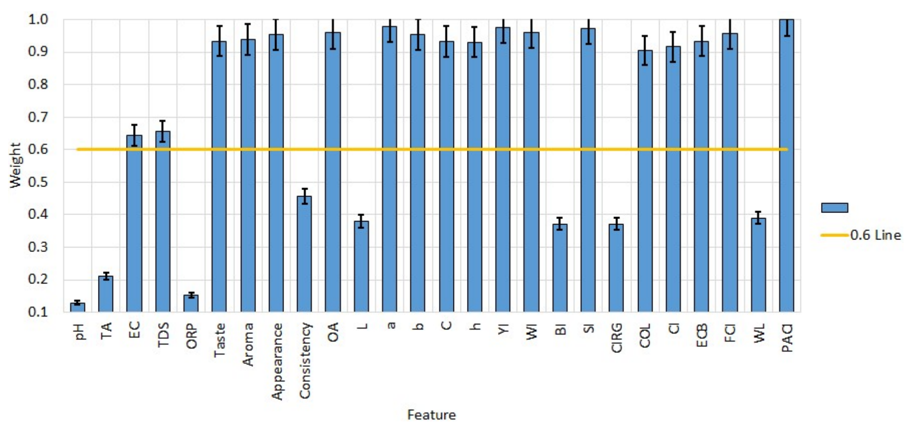

Figure 7. *Feature selection for lactic acid drink with rosehip flour*
All data have statistically significant difference at $p<0.05$

Selection data are summarized in a vector of 17 characters. The vector has the following form:

FV=[EC TDS Taste Aroma Appearance a b C h YI WI SI COL CI ECB FCI PACI] (20)

The feature vector data is reduced to two principal components. These components describe over 95 % of the source data in the feature vector. A regression model was constructed, which has a coefficient of determination R^2 = 0.89. The sum of squared errors is SSE = 1.11. Root mean square error is RMSE = 1.05. The results show that the obtained model describes the experimental data with sufficient accuracy.

The regression model has the form:

$$RHF = 0.96 + 3.4 \times {PC_1}^2 + 21.5 \times {PC_2}^2 + 18.5 \times PC_1 \times PC_2 \quad (21)$$

Figure 8 shows a graph of the appropriate value of rose hip flour addition in a milk-sour drink. The resulting appropriate value of the amount of rose hip flour is plotted. A suitable amount of 0.53 % of the additive was determined. This amount is acceptable to consumers and does not significantly change the physico-chemical, organoleptic and color characteristics of the lactic acid drink.

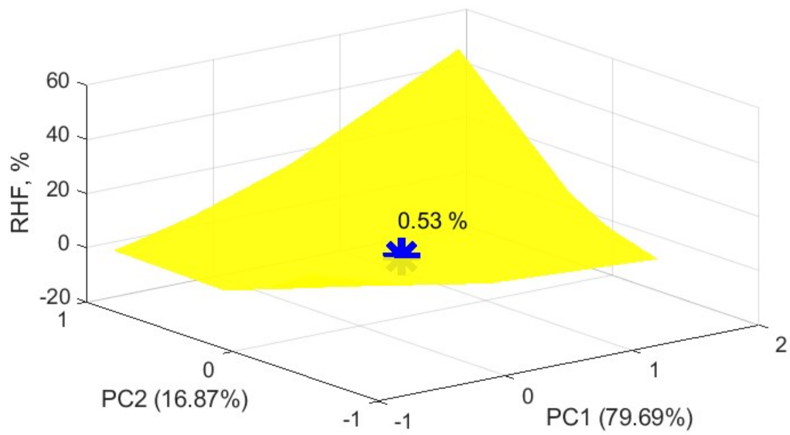

Figure 8. *Determining the appropriate amount rosehip flour in lactic acid drink*

Comparative analysis of the obtained results

Table 7 shows the results of a comparative analysis of lactic acid drinks with coarsely ground rose hips and rose hip flour. Increasing the addition of rose hips leads to an increase in the acidic character of the final product, regardless of the type of addition.

Table 7. *Results from comparative analysis of lactic acid drink with rosehip*

Additive / **Characteristic when increasing the amount of the additive**	**Grounded rosehip**	**Rosehip flour**
Physico-chemical characteristics	Increase in acid character	Increase in acid character
Organoleptic evaluation	Improvement	Aggravation
Color characteristics	Changes at: a (Lab), YI, COL, CI, ECB, FCI, WL, PACI	Changes at: a, b (Lab), C (LCh), YI, SI, COL, CI, ECB, WL, PACI
Number of informative features	17	17
Regression model, R^2	0.97	0.89
Admissible amount of the additive, %	2.76	0.53

Coarsely ground rosehip improves the organoleptic characteristics of the product. On the other hand, with rose hip flour, the organoleptic characteristics deteriorate with larger amounts of the additive. A higher number (ten) of the informative color indices was observed for the drink with rose hip flour, while for those with coarsely ground supplement it was eight. Comparing the obtained regression models, it can be considered that for the lactic acid drink with coarsely ground rosehip, the model describes the experimental data more accurately than the product with the addition of plant flour. The permissible quantities of coarsely ground rose hips are greater than those of flour. This is probably due to preserving the integrity of the rosehip husk, improving the organoleptic evaluation and improving the consistency of the lactic acid drink, due to the absorption of the separated spike.

The obtained results for low *p*H values and increased values of titratable acidity of the obtained lactic acid drinks with the addition of coarsely ground rosehip fruit confirm the results of Küçüköner *et al*. [6] who added 10 % rosehip marmalade to yogurt.

The established permissible amount of 0.53 % of rose hip flour complements the results of Turek *et al*. [7], who also found a deterioration of the overall organoleptic evaluation of the resulting dairy products when rosehip oil was added,

Similar results of impaired organoleptic evaluation were reported by Dabija *et al*. [8], with the addition of 1.5 % rosehip flour in yogurt, as well as the results obtained by Kulaitiene *et al*. [9], with the addition of 1 % rose hip flour in lactic acid pellets.

The methods proposed in this work can be used to improve the results of Zhelyazkova *et al*. [10] and Alzamara *et al*. [11], in determining the optimal amount of additives in the preparation of lactic acid beverages.

CONCLUSIONS

The physicochemical, organoleptic and color characteristics of a lactic acid drink with coarsely ground rosehip and rosehip flour were determined. Appropriate statistical methods were used, through which the informativeness of these characteristics was established, regression models were developed and the optimal amounts of addition of ground rose hips in the product were defined based on them.

An analysis was made of a total of 26 characteristics describing the change in the physico-chemical, organoleptic and optical properties of a sour-milk drink with the addition of ground rose hips. Only 17 of them were found to be informative.

Regression models have been developed that describe the reduced experimental data and their relationship to the amount of added rosehips with an accuracy of 89 - 97 %. Based on the data from these models, the optimal amount of the additive in sour-milk drinks is defined.

The optimal amounts of the two additives were determined. It was established that for lactic acid drinks with the addition of coarsely ground rosehip fruits, the optimal amount is 2.76 %, and with the addition of rosehip flour - 0.53 %. These amounts improve the organoleptic characteristics and nutritional value of lactic-acid drinks, making them acceptable to consumers to a sufficient extent.

The results of this development complement and to some extent improve those proposed in the available literature by determining optimal amounts of additives in dairy products.

The results obtained in this study can be used in the production of lactic acid drinks with the addition of ground rose hips, and the proposed tools can be used in the development of methodologies for the valorization of waste products from food production and their addition to dairy products.

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