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Designing functional beverages with the addition of fulvic acids for physically active people

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Abstract
We carried out research to propose an innovative functional beverage targeted primarily at physically active people and based only on natural additives obtained from plants, waters, and soils. Fulvic acids have numerous health-enhancing qualities, which qualifies them to be valuable, organic drink additives. Not only is the content of minerals or vitamins of the product important to the consumer, but so are its organoleptic properties. Color and flavor, followed by price, are equally crucial elements in the design of a product in order to achieve market success.
This paper presents the results of sensory analysis conducted on 16 drinks with various compositions. Functional water, along with fulvic acids, was also enriched with lemon, chokeberry, aloe, elderberry, and blackcurrant juice, etc. This analysis is the basic differentiator in determining the parameters of new food products. This study was carried out in collaboration with a trained expert panel, which guaranteed objectivity and ensured proper, reliable product quality assessment.

Keywords: functional beverages, fulvic acids, innovative products

1. Introduction
A good project for the creation of a new food product for the market should be directed towards a specific target group. The analysis requires an estimation of market needs, data collection on the competition, a detailed description of product properties, and the identification of opportunities, threats, strengths, and weaknesses, as well as cost statements or potential sources of financing [1].
What guarantees the product's success on the market is its innovative qualities. Companies that skillfully use the latest technologies and market experience and focus on satisfying and creating new consumer needs will gain a competitive advantage. When introducing pioneering food products, manufacturers who use new technologies, recipes, and packaging obtain a very good-quality product and adapt it to the expectations of consumers.
Currently, functional food is a very popular market sector. Consumers are paying more and more attention to the quality of products and the composition of the foods they consume. Healthy and bioactive ingredients are often the distinguishing features of goods selected for purchase.
The health information and nutrition claims provided by producers on product labels—in accordance with Regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods—may be helpful in making customer choices [2].
In addition, during the market launch of functional foods, it is important to pay attention to eating habits, current trends, demographic and economic factors, communication about product values and opinions, and information provided by the immediate social environment of the consumer (family and friends). Knowledge on detailed consumer requirements and product launch strategies can lead to the acceptance of the new product being introduced to the market by manufacturers [3].
We designed a new functional product, that is, a fulvic acid beverage, after collecting information on the preferences of a potential group of consumers: people with higher levels of physical activity. We analyzed the results of laboratory tests which were carried out on commercially available waters and functional beverages, and we assessed selected aspects of health-enhancing fulvic acids by determining their content of mineral components and demonstrating their antioxidant capacity. The next stages of research were carried out in order to propose an innovative functional beverage primarily for physically active people, based only on natural additives obtained from plants, waters, and soils, which will provide a significant amount of valuable mineral components, have appropriate health benefits, and, additionally, will be attractive to consumers in terms of flavor and color.
After specifying the original composition of the product, another study was planned: a sensory evaluation. Such analyses are the basic differentiators in determining the parameters of new food products. This study was carried out in collaboration with a trained expert panel, which guaranteed objectivity and ensured that the product underwent proper, thorough quality assessment.

2. Fulvic acids
Fulvic acids are components of humic substances of a complex structure, without a standard chemical formula, occurring in soil and plants in trace amounts [4]. Humic substances are the most widespread natural complexing ligands found in nature. Yellow to brown soil may contain a lot of fulvic acids, while dark brown to black soil may be enriched with significant amounts of humic acid and humin [5].
An analysis of the properties of fulvic acids showed that they are a valuable raw material because they stimulate blood formation and energy production and they prevent hypoxia. They actively participate in the transport of nutrients to deep tissues and help overcome fatigue. They

also effectively act to strengthen the cardiovascular, gastric, and nervous systems and as an anti-stress factor [6].

Study findings for fulvic acid properties conducted by Kishor *et al*. [7], for example, suggest that humic substances, consisting of 60%–80% fulvic acids, have anti-cancerogenic properties. Their use may be beneficial in the treatment of cancer due to the chelating properties exhibited by heavy metals, as proven in several studies [8, 9, 10, 11]. Until now, fulvic acids as a product have been used primarily to support plant growth and maintain adequate soil moisture. Currently, the food market is developing an interest in them as well. Taking into consideration all the properties of fulvic acids, it is possible to use them as new, natural, and valuable food additives or dietary supplements [12]. Results of the other own study, conducted on fulvic acids concentrates and ready-to-drink beverages available on the market as dietary supplements, showed that they contain significant amounts of Fe, Mg and Mn. In addition, these products can have antioxidant capacity as they are a good source of polyphenolic compounds [13].

3. The aim of the study

The aim of the study was to develop innovative functional beverages enriched with fulvic acids. We intended to determine the right composition to ensure the sensory quality of the products and to eliminate the characteristic taste of fulvic acids.

The goal of the research was to prepare a recipe for new products, which increases the health values of beverages thanks to a specific additive. The product is targeted at physically active people. Our analyses were preceded by an assay of the content of minerals, vitamins, and polyphenolic compounds in selected fulvic acids.

4. Materials and Method

Seven functional beverages available on the Polish and foreign markets—four waters with high mineral content and one functional water available on the American market—were selected for laboratory tests. In addition, we prepared our original products based on Jantar mineral water (manufacturer: Jantar Mineral Water) with the addition of various amounts of fulvic acid solutions purchased in the online store in 2018.

Our product was preceded by numerous laboratory tests assessing the composition of selected fulvic acids. The analysis of the presence of minerals and vitamins, as well as antioxidant properties, color, flavor, and gross price allowed the selection of two fulvic acids, labelled A and B for further experiments.

Table 1 shows the parameters of fulvic acids selected for the original product and their trade names.

Table 1: Fulvic acids

	Fulvic acid	Producer
A	Pure organic minerals	Good health naturally
B	SUPERIONIC OMICA	Omica Organics

Fulvic acid A had a high iron content (13.0 ± 1.1 mg/mL). The daily requirement was about 50%. They also had a fairly pleasant taste and antioxidant properties and the price for the maximum daily dose was the lowest among the products.

Fulvic acid B was selected for further analysis due to the high amount of magnesium (50 ± 2.3 mg/mL), the affordable gross price (approx. 0.50 EUR or approx. 2.50 PLN) per daily dose, but mainly due to its bright color and neutral flavor.

In order to formulate the recipe of the original functional drink, we used the organoleptic evaluation method. At the beginning, we selected additives which, according to available scientific data, contain ingredients valuable for human health and have antioxidant properties. The selection of the ingredients was also followed by extensive research on consumer preferences of the taste and color of beverages.

Samples for evaluation were prepared on the basis of Jantar mineral water with the addition of fulvic acids A and B. The organoleptic analysis of each sample included the color and flavor rating of beverages on a 5-point scale.

The study was carried out in 2018. From the moment of purchase until the analysis, all products and additives used in the study were stored in accordance with the manufacturer's instructions.

Table 2 summarizes the additives that were suggested for the first organoleptic evaluation of the original product. Additives in the form of liquid, extract, or powder were selected.

Table 2: Selected additives

Number	Additives Name
I	Juice from aronia
II	Juice from the black elderberry
III	Nettle juice
IV	Noni juice
V	Blackcurrant juice
VI	Pigwy juice
VII	Aloe
VIII	Coconut milk
IX	Citric acid
X	Birch juice
XI	Lemon juice
XII	Powder spirulina
XIII	Acai extract
XIV	Coconut milk
XV	Elderberry extract
XVI	Ground guarana

4.1 Sensory Analysis

The prepared drinks were subjected to sensory evaluation made by a specialized expert panel. Eight people trained in quantitative measurement of product quality and sensory intensity in terms of selected distinguishing features participated in the study.

Apart from the addition of juice or extract, the same amount of lemon juice was added to each product (except for products with added citric acid and the product that already contained lemon juice; 10 ml more lemon juice was added to this product than to the others). The lemon juice had a positive effect on the flavor and color of the product.

Table 3 presents the characteristics of the functional beverages prepared for the study. New product specifications are provided (the number used for organoleptic evaluation is given in parentheses), along with the composition and amount of additive. There were 32 products in total; they were divided into three sets according to color and additive. Set 1 contained beverages with the fulvic acids previously labelled A and B and with the addition of guarana and spirulina. Set 2 consisted of drinks with lemon juice and citric acid. Set 3 included products

with elderberry juice, acai berry extract, and one functional drink with fulvic acids already available on the market, in order to compare the results between the new products under design and a similar type of commercially available product. The amounts of fulvic acids and additives constituted the maximum recommended daily dose specified by the producers on the packaging.

Table 3: Composition of the functional beverages prepared for the study

Product	Composition	Quantity		Product No.	Composition	Quantity	
SET I							
I-1 (A-XVI)	Fulvic acid A	0.7	mL	I-2 (B-XVI)	Fulvic acid B	2.8	mL
	Jantar Mineral Water	469.3	mL		Jantar Mineral Water	467.2	mL
	ground guarana	2	g		ground guarana	2	g
	lemon juice	30	mL		lemon juice	30	mL
I-3 (A-XII)	Fulvic acid A	0.7	mL	I-4 (B-XII)	Fulvic acid B	2.8	mL
	Jantar Mineral Water	469.3	mL		Jantar Mineral Water	467.2	mL
	spirulina	2	g		spirulina	2	g
	lemon juice	30	mL		lemon juice	30	mL
SET II							
II-1 (A-XI)	Fulvic acid A	0.7	mL	II-2 (B-XI)	Fulvic acid B	2.8	mL
	Jantar Mineral Water	459.3	mL		Jantar Mineral Water	457.2	mL
	lemon juice	40	mL		lemon juice	40	mL
II-3 (A-IX)	Fulvic acid A	0.7	mL	II-4 (B-IX)	Fulvic acid B	2.8	mL
	Jantar Mineral Water	497.3	mL		Jantar Mineral Water	495.2	mL
	citric acid	2	g		citric acid	2	g
SET III							
III-1 (A-II)	Fulvic acid A	0.7	mL	III-2 (B-II)	Fulvic acid B	2.8	mL
	Jantar Mineral Water	419.3	mL		Jantar Mineral Water	417.2	mL
	juice from the Black Elderberry	50	mL		juice from the Black Elderberry	50	mL
	lemon juice	30	mL		lemon juice	30	mL
III-3 (A-XV)	Fulvic acid A	0.7	mL	III-4 (B-XV)	Fulvic acid B	2.8	mL
	Jantar Mineral Water	469.3	mL		Jantar Mineral Water	467.2	mL
	elderberry extract	2	g		elderberry extract	2	g
	lemon juice	30	mL		lemon juice	30	mL
III-5 (A-XIII)	Fulvic acid A	0.7	mL	III-6 (B-XIII)	Fulvic acid B	2.8	mL
	Jantar Mineral Water	469.3	mL		Jantar Mineral Water	467.2	mL
	Acai extract	2	g		Acai extract	2	g
	lemon juice	30	mL		lemon juice	30	mL
				III-7 (VII)	"Blk water"	500	ml

The assessment was carried out in accordance with the applicable ISO standards—PN-ISO 6564: 1999, PN-ISO 6658: 1998, and PN-ISO 8586-1: 1996. In accordance with the requirements of PN-ISO 8586-1: 1996, all assessors had the necessary skills to concentrate, express, and describe the qualitative features, their impressions, motivation, and interest. The testers were informed before the study about the need for objective analysis.

Twelve one-dimensional sensory descriptors were selected for sensory evaluation. The objective of the study was to analyze all the features of the new product under development, which is why these descriptors included features of appearance (color tone, clarity, and occurrence of sediment), odor (fresh smell or foreign smell), and flavor (sour, sweet, tart, astringent, bitter, other fruit, or foreign), as well as an overall product rating. Definitions and edge scale specifications for individual sensory descriptors are shown in Table 4.

Table 4: Definitions of sensory descriptors and scale edge specifications used in the profile assessment of proprietary products

Descriptor	Definition	Scale Edge Specifications
Features of Appearance		
Color Tone	Optical impression of the beverage color	(1) Light–Dark (10)
Clarity	The degree of light transmittance	(1) Clear–Opaque (10)
Occurrence of Sediment	Solid particles of the tested product depositing at the bottom of the vessel	(1) No sediment–Large amount of sediment (10)
Features of Odor		
Fresh Odor	Odor characteristic of freshly squeezed lemon juice; refreshing	(1) Undetectable–Very intense (10)
Foreign Odor	Unusual odor for a beverage with the addition of lemon juice; if you smell it, note its quality on the card	(1) Undetectable–Very intense (10)
features of flavor		
Sweet	Corresponding to the basic flavor of, e.g., sucrose	(1) Undetectable–Very intense (10)
Sour	Corresponding to the basic flavor of, e.g., sucrose	(1) Undetectable–Very intense (10)
Tart/Astringent	Characteristic of sour, underripe citrus fruits; giving the impression of puckering and tingling in the mouth	(1) Undetectable–Very intense (10)

Bitter	It corresponds to the basic flavor of, e.g., quinine	(1) Undetectable–Very intense (10)
Other Fruit	Typical of fruit other than lemon; if you taste this, note its quality on the evaluation card	(1) Undetectable–Very intense (10)
Foreign Flavor	Flavor not typical of any fruit; if you taste this, note its quality on the card	(1) Undetectable–Very intense (10)
Overall Assessment		
Overall Assessment	General sensory impression when assessing a beverage with the addition of lemon juice, taking into account all the differentiators and their mutual harmonization	(1) Bad quality–Very good quality (10)

The intensity of each differentiator was assessed on a 10-centimeter unstructured linear scale.

The samples of all beverages which were submitted to the assessment of overall appearance, color, flavor, odor, and overall impression were served in clean, transparent 150-mL glass vessels containing approximately 100 mL of the product at room temperature. The samples were encoded with random three-digit numbers and presented to the assessors in random order.

The testers also received water to neutralize the taste before evaluating the next sample of a beverage. The intensity of all differentiators for each drink was assessed during one session.

5. Results and Discussion

5.1 Organoleptic evaluation

The results of the organoleptic assessment were divided according to the addition of a specific fulvic acid product.

Table 5 summarizes the results of the color and taste evaluation of the new beverage; whose main ingredient was fulvic acid concentrate and one of the additives listed in Table 2. A total of 16 different beverage samples were evaluated. The table contains the values for color and flavor evaluation. The weight for color was 0.4, for flavor 0.6. The "RESULT" column displays the sum of the two distinguishing features of the drink. The higher the score, the better the overall rating of the drink.

Table 5: Evaluation of the color and taste preferences of the proposed beverages with fulvic acid A

	Color	Weight of color	Color Total	Taste	Weight of taste	Taste total	Result
A-I	4	0.4	1.6	3.5	0.6	2.1	3.7
A-II	5	0.4	2	4	0.6	2.4	4.4
A-III	3	0.4	1.2	2	0.6	1.2	2.4
A-IV	2	0.4	0.8	1	0.6	0.6	1.4
A-V	5	0.4	2	4	0.6	2.4	4.4
A-VI	2	0.4	0.8	2	0.6	1.2	2
A-VII	2.5	0.4	1	1	0.6	0.6	1.6
A-VIII	1.5	0.4	0.6	1	0.6	0.6	1.2
A-IX	4.5	0.4	1.8	5	0.6	3	4.8
A-X	4	0.4	1.6	2	0.6	1.2	2.8
A-XI	5	0.4	2	4.5	0.6	2.7	4.7
A-XII	3.5	0.4	1.4	4	0.6	2.4	3.8
A-XIII	4.5	0.4	1.8	4.5	0.6	2.7	4.5
A-XIV	4	0.4	1.6	2	0.6	1.2	2.8
A-XV	5	0.4	2	5	0.6	3	5
A-XVI	4	0.4	1.6	4	0.6	2.4	4

Similarly, Table 6 contains the results of an organoleptic assessment of fulvic acid beverages labelled as B. Overall, 32 products were rated.

Table 6: Evaluation of the color and taste preferences of the proposed beverages with fulvic acid B

	Color	Weight of color	Color total	Taste	Weight of taste	Taste total	Result
B-I	3	0.4	1.2	3.5	0.6	2.1	3.3
B-II	4.5	0.4	1.8	4.5	0.6	2.7	4.5
B-III	2	0.4	0.8	1	0.6	0.6	1.4
B-IV	2.5	0.4	1	1	0.6	0.6	1.6
B-V	4	0.4	1.6	4	0.6	2.4	4
B-VI	2	0.4	0.8	2	0.6	1.2	2
B-VII	2.5	0.4	1	1	0.6	0.6	1.6
B-VIII	1.5	0.4	0.6	1	0.6	0.6	1.2
B-IX	4	0.4	1.6	5	0.6	3	4.6
B-X	4	0.4	1.6	2	0.6	1.2	2.8
B-XI	4.5	0.4	1.8	4.5	0.6	2.7	4.5
B-XII	3	0.4	1.2	4	0.6	2.4	3.6
B-XIII	4	0.4	1.6	4.5	0.6	2.7	4.3
B-XIV	4	0.4	1.6	2	0.6	1.2	2.8
B-XV	4.5	0.4	1.8	5	0.6	3	4.8
B-XVI	3.5	0.4	1.4	4	0.6	2.4	3.8

Based on the initial organoleptic evaluation, 14 products were finally selected for further sensory evaluation studies (Table 7). The highest rated products were those with the addition of elderberry juice (II), blackcurrant (V), lemon (IX), citric acid (XI), spirulina powder (XII), acai extract (XIII), elderberry extract (XV), and guarana (XVI).

Table 7 shows the specifications of fulvic acids and the additives included in the beverages whose color and taste were rated the highest.

Table 7: The products which were rated highest for color and flavor and their composition

	Composition		Composition
A-II	Fulvic acid A	B-II	Fulvic acid B
	Jantar Mineral Water		Jantar Mineral Water
	juice from the Black Elderberry		juice from the Black Elderberry

A-IX	Fulvic acid A	B-IX	Fulvic acid B
	Jantar Mineral Water		Jantar Mineral Water
	citric acid		citric acid
A-XI	Fulvic acid A	B-XI	Fulvic acid B
	Jantar Mineral Water		Jantar Mineral Water
	Lemon juice		Lemon juice
A-XII	Fulvic acid A	B-XII	Fulvic acid B
	Jantar Mineral Water		Jantar Mineral Water
	spirulina		spirulina
A-XIII	Fulvic acid A	B-XIII	Fulvic acid B
	Jantar Mineral Water		Jantar Mineral Water
	Acai extract		Acai extract
	Lemon juice		Lemon juice
A-XV	Fulvic acid A	B-XV	Fulvic acid B
	Jantar Mineral Water		Jantar Mineral Water
	elderberry extract		elderberry extract
A-XVI	Fulvic acid A	B-XVI	Fulvic acid B
	Jantar Mineral Water		Jantar Mineral Water
	ground guarana		ground guarana

5.2 Sensory evaluation

The results of the parameters evaluated by all testers were converted into average values and are presented together with the standard deviation in Tables 8 and 9.

Table 8: Mean values and standard deviations of sensory descriptors of the tested beverages

Product	Acid taste	Sweet taste	Bitter taste	Astringent taste	Tasty fruit	Tasty foreign
SET I						
I-1	6.54 ± 1.50	0.45 ± 0.83	2.41 ± 2.52	3.25 ± 3.36	1.81 ± 3.21	0.39 ± 0.78
I-2	6.45 ± 1.45	0.45 ± 0.83	2.38 ± 2.73	3.63 ± 2.96	1.15 ± 2.44	0.26 ± 0.74
I-3	4.71 ± 2.22	0.44 ± 0.90	0.75 ± 0.93	1.94 ± 1.54	1.35 ± 2.49	2.30 ± 3.12
I-4	4.94 ± 0.73	0.44 ± 0.90	1.50 ± 1.56	1.58 ± 1.48	1.28 ± 1.21	1.33 ± 3.12
SET II						
II-1	4.21 ± 2.03	1.14 ± 2.05	1.79 ± 2.49	3.03 ± 3.38	2.55 ± 3.54	1.25 ± 1.84
II-2	4.94 ± 1.90	0.83 ± 2.10	2.41 ± 2.33	3.84 ± 2.89	2.69 ± 3.74	1.13 ± 1.75
II-3	8.68 ± 1.01	0.20 ± 0.39	1.65 ± 2.15	6.49 ± 4.30	0.88 ± 1.83	2.00 ± 3.79
II-4	6.73 ± 1.38	0.26 ± 0.41	1.18 ± 1.39	4.50 ± 3.62	1.06 ± 2.02	1.61 ± 3.02
SET III						
III-1	6.13 ± 2.19	0.60 ± 1.03	1.81 ± 3.07	4.95 ± 3.26	4.79 ± 3.37	0.21 ± 0.60
III-2	5.31 ± 2.04	0.85 ± 1.17	1.54 ± 2.89	4.84 ± 3.43	4.39 ± 3.19	0.21 ± 0.60
III-3	6.28 ± 2.43	0.85 ± 1.44	1.66 ± 2.66	4.63 ± 3.31	2.36 ± 3.07	0.21 ± 0.60
III-4	5.59 ± 3.09	0.79 ± 1.32	1.66 ± 3.07	4.24 ± 3.20	2.31 ± 3.33	0.40 ± 0.74
III-5	1.03 ± 1.10	7.95 ± 1.55	0.20 ± 0.39	0.21 ± 0.40	4.06 ± 2.71	1.88 ± 3.48
III-6	0.74 ± 0.76	7.86 ± 1.57	0.13 ± 0.35	0.13 ± 0.35	4.83 ± 2.28	2.25 ± 3.25
III-7	0.10 ± 0.21	0.09 ± 0.18	1.08 ± 2.03	0.68 ± 1.47	0.00 ± 0.00	1.75 ± 2.73

Analyzing the above table, it can be concluded that only the beverage with the addition of acai extract (III-5 and III-6) had a sweet flavor, in contrast to the sour flavor that was noticeable in all beverages except those with the addition of acai (III-5 and III-6) and the commercially available product "blk. Water" (III-7; manufacturer: blk. International, LLC). A bitter flavor was only detectable at a level from 0.13 (beverage III-6) to 2.41 (beverages I-1 and II-2). According to the assessors, a tart, astringent flavor was most noticeable in the beverage with the addition of citric acid and fulvic acid A (II-3). Drinks with acai extract (III-6) and elderberry juice (III-1) were characterized by the greatest palatability of fruit. The average values of this descriptor were 4.83 and 4.79, respectively. The assessors indicated that a foreign flavor, if any, was perceptible as "medicine-like," perhaps due to the characteristic taste of fulvic acids.

Table 9: (Continued) Mean values and standard deviations of sensory descriptors of the tested beverages

Product	Color tone	Clarity	Sediment	Fresh fragrance	Foreign odor	Rating
SET I						
I-1	5.23 ± 2.59	6.50 ± 1.52	7.10 ± 2.20	4.58 ± 2.49	1.44 ± 2.81	3.19 ± 1.60
I-2	4.14 ± 2.37	5.55 ± 1.66	5.44 ± 2.21	5.56 ± 2.04	0.76 ± 1.36	3.58 ± 2.16
I-3	3.70 ± 2.18	4.76 ± 2.20	4.75 ± 1.97	3.08 ± 2.00	3.03 ± 3.23	1.86 ± 1.62
I-4	2.70 ± 1.75	4.06 ± 2.67	4.24 ± 2.12	3.36 ± 2.05	2.34 ± 3.36	1.90 ± 1.70
SET II						
II-1	3.66 ± 2.02	6.56 ± 1.03	5.21 ± 2.11	7.01 ± 1.64	0.13 ± 0.35	3.71 ± 1.36
II-2	1.93 ± 1.75	6.71 ± 1.10	5.04 ± 2.02	6.75 ± 1.79	0.56 ± 1.24	3.00 ± 1.81
II-3	3.09 ± 2.38	0.10 ± 0.26	0.30 ± 0.37	0.75 ± 1.10	1.35 ± 3.15	1.49 ± 1.49
II-4	0.11 ± 0.19	0.06 ± 0.15	0.06 ± 0.18	0.48 ± 1.07	0.25 ± 0.63	2.28 ± 1.53

SET III						
III-1	4.80 ± 1.34	4.14 ± 1.16	5.86 ± 1.60	4.40 ± 3.43	2.80 ± 2.40	3.00 ± 2.60
III-2	3.95 ± 1.49	3.30 ± 1.98	4.25 ± 2.35	5.15 ± 3.28	3.23 ± 2.05	4.05 ± 2.31
III-3	3.86 ± 1.63	5.03 ± 1.88	4.43 ± 1.79	4.41 ± 2.11	1.33 ± 1.21	2.89 ± 1.22
III-4	2.63 ± 0.86	4.17 ± 1.93	2.79 ± 1.75	3.79 ± 2.15	1.69 ± 1.72	2.54 ± 1.13
III-5	8.20 ± 0.89	5.93 ± 1.92	7.16 ± 0.93	0.54 ± 0.70	8.66 ± 1.26	4.94 ± 2.90
III-6	7.46 ± 0.94	5.44 ± 2.36	6.48 ± 1.45	0.85 ± 0.94	7.75 ± 1.35	5.04 ± 2.61
III-7	9.63 ± 0.46	0.30 ± 0.57	0.00 ± 0.00	0.29 ± 0.81	0.23 ± 0.32	0.73 ± 0.58

The drink with the addition of citric acid and based on fulvic B (II-4) acids had the lightest color. The difference in the mean color value between citric-acid beverages with fulvic acids A and B, as assessed by experts, is 2.98, which may be caused by the effect of the color of fulvic acids alone. The darkest and one of the clearest products was the Blk Water (III-7). Clarity values for all beverages were between 0.06 and 6.71. Blk Water (III-7) contained no sediment according to the assessors. Drinks with lemon juice (II-1 and II-2) had the freshest smell. On the other hand, a foreign odor was most noticeable in beverages with the addition of acai berry extract (III-5 and III-6), which were also rated highest. The functional water available on the market—blk. Water, marked as no. III-7—received the worst score, with an average overall rating of only 0.73.

The average descriptor values differed between beverages that belonged to the same sets. There were also differences in sensory assessment between products differing only in the type of fulvic acids added (A and B).

Figures 1–3 present the sensory profiles of the tested beverages from Sets 1, 2, and 3 in the form of radar charts, taking into account all of the assessed factors. The charts are presented in order to compare the sensory evaluation of products grouped into individual sets and to better visualize the test results.

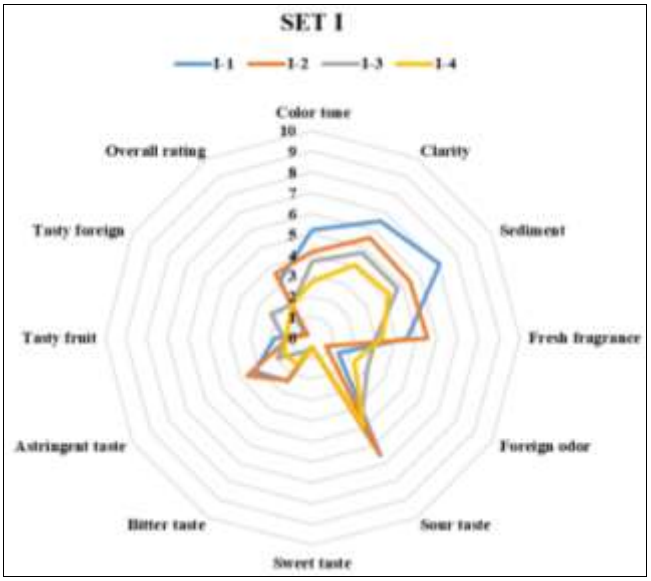

Fig 1: Results of the evaluation of beverage descriptors from Set I

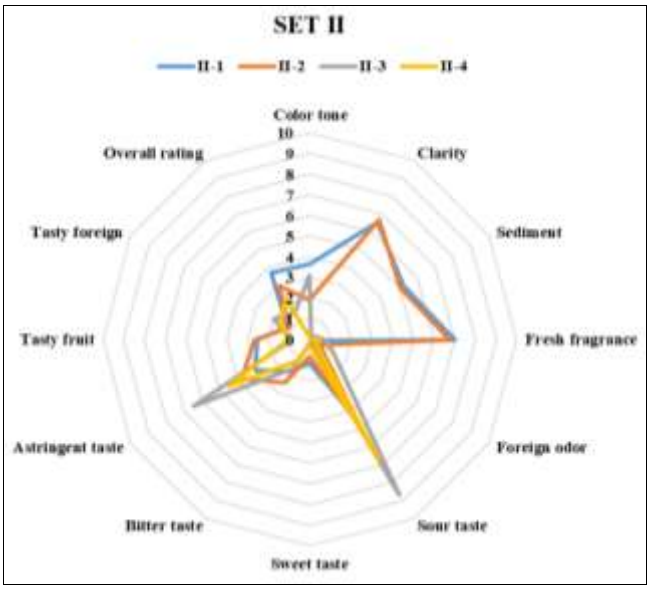

Fig 2: Results of the evaluation of beverage descriptors from Set II

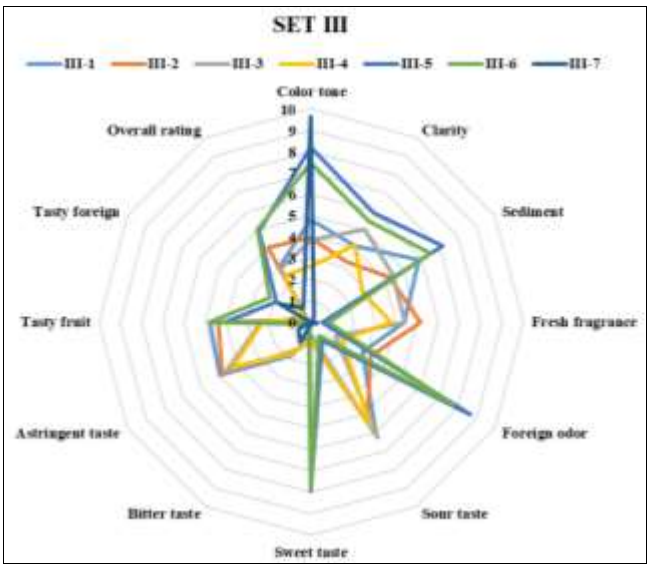

Fig 3: Results of the evaluation of beverage descriptors from Set III

6. Conclusion

Due to the thorough sensory analysis carried out by the expert panel, taking into account flavor, color, odor, and the functional properties of proprietary products, it can be assumed with high likelihood that consumers (especially the target group) will accept and drink the beverages. Our study allowed us to distinguish the possible quality parameters of beverages proposed by consumers.

The highest-rated drinks were beverages with the addition of fulvic acids A and B and acai berry extract, despite the fact that they also had the most noticeable foreign odor. In addition, these drinks were not very clear and sediment was observed in them. The taste of the fruit and the sweet flavor was rated quite high compared to other drinks.

The lowest average overall rating from the group of drinks with an original recipe was given to drinks from Set I with fulvic acids A and B and spirulina, as well as those from Set 2 with the addition of fulvic acid A and citric acid. The drinks were characterized by a sour taste, low fruit palatability, and almost undetectable sweet flavor.

Comparing the quality features of beverages rated highest and lowest overall, you can choose those parameters that may be most relevant to consumers and affect their purchasing decisions and preferences. Analyzing the findings, it can be concluded that the most important qualitative factors that affect the overall perception of the drink are a noticeable sweet taste and the palatability of fruit. Foreign odor and clarity are not important and do not affect the general impression of the beverage. Flavor is very important during the design stage of food products and should be crucial for producers when creating the composition of functional drinks. Therefore, beverages containing fulvic acids and acai berries, which, in addition to having functional values, were rated the highest and have good flavor characteristics, will be further promoted because they have the best chance to succeed on the functional drinks market.

Declarations of interest

None.

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