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STUDY OF THE QUALITY, SAFETY, AND EFFICACY OF NON-ALCOHOLIC ENERGY DRINKS.

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Abstract: The article presents the results of an open consumer tasting: intensity and duration of the tonic effect of soft energy drinks.The Tasting Committee members were offered drinks to be in high demand according to the preliminary marketing survey. During the working process the experts made the organoleptic assessment, tested the point scale, carried out the statistical analysis of the data and made some methodological recommendations of assessment of organoleptic characteristics of soft energy drinks.

Key words: Point scale; safety; tasting; intensity; quality; organoleptic; duration; efficacy.

Despite their popularity, non-alcoholic energy drinks (NAED) have not been sufficiently evaluated for their quality and safety. A scoring system has not been developed that could facilitate an objective assessment and competitiveness of the products in question . NAEDs are primarily consumed by young people, including those with heightened psycho-emotional sensitivity. There is a need to develop a system for evaluating the organoleptic properties of NAEDs, as well as to determine the intensity and duration of their stimulating effect .In the first stage of the research, an open consumer tasting of NAEDs was conducted. The beverages presented were those that, according to a preliminary survey of consumers, are the most in demand: Red Bull, Bullit, Burn, Adrenaline Rush, Adrenaline Nature, Drive Me, Super Max, Flash, Tornado, Tornado Ice, Spring Energy.In accordance with GOST R 52844-2007, the organoleptic evaluation indicators were selected: appearance, color, aroma, and taste. A 10-point scale and a table of verbal descriptions were created based on the importance of the parameters. Considering the transformation from a 10-point scale to a 100-point scale, the sum of the weighting coefficients was equal to 10. The coefficients for appearance and taste were set at three, while those for color and aroma were set at two .

Based on the results of the tasting, an organoleptic evaluation of the beverages was provided. Subsequently, the scoring scale was tested, and statistical processing of the obtained

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data was conducted. Each participant in the sensory analysis filled out their own questionnaire, taking into account the developed scoring scale, quality indicators, and weighting coefficients.

The results of the tasting demonstrate that the highest scores are characteristic of the NAED brands (TM) Adrenaline Rush, Red Bull, and Super Max; the lowest scores were for Tornado Ice and Adrenaline Nature. Participants in the tasting committee noted the most prioritized quality indicators (aroma and taste) that shape the consumer properties of the beverages. A visual comparison of the total scores for the NAEDs is presented in Table 1.

The data from the table indicate that the highest total scores were received by the NAED brands Adrenaline Rush (9.575 points), Red Bull, and Super Max (both with 9.125 points each); the lowest scores were for Tornado Ice (7.375 points), Adrenaline Nature (7.625 points), and Flash (7.875 points). It can be assumed that the manufacturers of the NAED brands Adrenaline Rush, Red Bull, and Super Max are focused on meeting consumer preferences.Statistical processing of the obtained data was conducted by calculating the arithmetic mean values of the individual indicators in points (X'), as well as calculating the standard deviation (S) for each individual indicator, which was computed using the formula.

$$S = \pm\sqrt{\left(\sum \frac{X_i^2}{n}\right) - X'^2}, \qquad (1)$$

where \(X_i\) is the individual score from one taster in points; \(n\) is the number of tasters; \(X'\) is the arithmetic mean value of the individual scores in points [2]. The absolute error (\(ΔX\)) and relative error (\(ε\)) were calculated, as well as a composite indicator (\(Q\)) using the formula.

$$Q = X_1' k_1 + X_2' k_2 + X_3' k_3 + X_4' k_4, \qquad (2)$$

where $X_1' - X_4'$ are the average scores of the individual quality indicators (appearance, color, aroma, taste); $k_1 - k_4$are the corresponding weighting coefficients of the individual indicators.

The statistical processing of the data, the sum of the individual indicators ($\sum X_i$), as well as the absolute and relative errors, are presented in Table 2.

The results of the conducted tasting are objective, as confirmed by statistical processing and calculations of the standard deviation on a 10-point scale, which amounted to 0.500. For clarity of assessments, the standard deviation (S) on a 10-point scale should not exceed ±1.0. The highest composite scores were characterized by the beverages Adrenaline Rush (24.875), Red Bull (23.750), and Super Max (23.625). The lowest scores were for Tornado Ice (18.875) and Adrenaline Nature (20.000).It was noted that Adrenaline Nature has an inappropriate color

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and an unbalanced taste with poorly masked additions of guarana and ginseng. The beverage Tornado Ice is characterized by an off taste with an unpleasant aftertaste.It was established that the most significant quality characteristics are aroma and taste. High taste characteristics were noted for the NAED brands Red Bull, Burn, and Adrenaline Rush, which received the highest scores and are prioritized over other NAED brands. Methodological recommendations for the system of evaluating the organoleptic properties of non-alcoholic tonic (energy) drinks have been developed. In the second stage of the research, the intensity and duration of the stimulating effect of NAEDs were determined.The study involved 60 individuals aged 18 to 23, including 32 males and 28 females, who were students at higher educational institutions in the Kemerovo region. The volunteers were divided into four groups of 15 people each, comparable in gender and age. The exclusion criteria for the study included acute inflammatory pathologies within two weeks prior to the start of the experiment, atopic constitutional anomalies, and individuals with arterial hypotension or hypertension.For the 1st and 2nd groups (test subjects), the NAEDs selected were those that received the highest ratings (Red Bull and Burn, respectively). Preliminary examination of their labeling revealed compliance with regulatory requirements. The 3rd group consumed a reference drink (30 mg of caffeine dissolved in 100 cm^3 of purified drinking water). The caffeine content is within the recommended levels for components that ensure an optimal stimulating effect according to GOST R 52844-2007. When selecting NAEDs, it was also considered that a safe intake of caffeine is 50-100 mg taken 2-3 times, totaling 150-300 mg per day [10]. The selected NAEDs contain 75 mg/250 cm^3 or 150 mg/500 cm^3 of caffeine. Based on this, the volume for assessing the stimulating effect of a single intake of NAED was set at 250 cm^3, which excluded the possibility of toxic effects. For the control group (4th group), a placebo drink was used, consisting of 50% purified drinking water and 50% clarified apple juice.

Drinks	Indicators, points			
	Image	colour	smell	flavor
Red Bull	3,000	2,000	1,625	2,500
Burn	3,000	2,000	1,750	2,250
Adrenaline Rush	2,750	2,000	2,000	2,875
Adrenaline Nature	2,500	1,375	1,500	2,250

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Bullit	3,000	1,875	3,275	2,000
Tornado	2,875	2,000	1,750	2,000
Tornado ice	2,875	2,000	1,250	1,250
Spring Energy	3,000	1,875	1,750	2,250
Flash	3,000	2,000	1,250	1,625
Super Max	2,750	2,000	1,750	2,625
Drive me	2,750	1,625	1,750	2,375

The objective for all participants in the study was the precise execution of the assigned tasks after a preliminary briefing. On the day of the experiment, the consumption of stimulating drinks (tea, coffee, NAEDs) was excluded. To achieve reliable results, participants consumed pasteurized drinking milk with a fat content of 2.5% in a volume of 250 cm³ the evening before and in the morning on the day of the experiment.

During the study, the groups of participants were isolated from each other. The assessment of the stimulating effect of the beverages was carried out using instrumental methods (thermometry, blood pressure measurement), a step test, the Shulte table, and the Burdon correction test [3, 9]. One day before the experiment, the subjects filled out a questionnaire that included personal data. The processing of the obtained materials was conducted using methods of variation statistics with the Student's t-test (STATISTICA 6.0 for Windows XP).

The variable observed between the sample means was calculated using the formula."$t_ф = \frac{x_{1cp}-x_{2cp}}{S_{x_{1cp}-x_{2cp}}} = \frac{d}{S_d}$ (3)

where x_{1cp} and $x_{2cp}$are the arithmetic means of the samples that are not correlated with each other; $S_{x_{1cp}-x_{2cp}}$ is the error of the difference between the sample means.

To compare the arithmetic means of the samples, it was assumed that the difference between them \(d\) occurred by chance [7, 11]. The criterion for testing this hypothesis was the variable observed between the sample means, which follows the Student's t-distribution with 28 degrees of freedom [11]. In this formula, the error of the difference between the sample means is denoted as \(S_d\) and is determined using the formula.

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$$S_d = \sqrt{\frac{\sum(x_i - x_{1cp})^2 + \sum(x_i - x_{2cp})^2}{n(n-1)}}, \quad (4)$$

where n is the number of observations.

To assess attention stability and work performance dynamics, as well as the effectiveness of work and degree of adaptation, the Shulte table method was used. The main indicators were the time taken to complete the task, the number of errors for each table, and the number of viewed symbols.

The Burdon proofread test was conducted individually and in groups. The Burdon proofread test was used to calculate the accuracy, productivity, and success of task completion. To determine the effectiveness of the experiment, the average was calculated for each group, and the statistical significance of the difference between these averages was determined.

In the initial variant, the body temperature of participants in all groups corresponded to that of a healthy person (36.0±0.1...36.4±0.1 °C). Systolic blood pressure was (111.5±3)–(123.1±3) mm Hg, diastolic blood pressure was (69.4±3)–(73.8±3) mm Hg, and pulse rate was (79±4)–(85±4) beats/min, which is typical for people in this age category.

After one hour of the experiment, an increase in systolic blood pressure and pulse rate was observed in the 1st, 2nd, and 3rd groups, which persisted for two hours. Body temperature and diastolic pressure changed little. After three hours, a return to the upper limits of blood pressure and pulse rate was noted. In the 4th group, the studied indicators changed only slightly, remaining within the typical range for the body in the evening.

Based on the results before and after beverage consumption, we can observe changes in the upper limit of blood pressure. In the 1st group, systolic blood pressure increased by 27.9±3 mm Hg, reaching 141.8±3 mm Hg. In the 2nd group, there was a more significant rise of 35.4±3 mm Hg, resulting in 152.9±3 mm Hg. In the 3rd group, the difference between the initial measurement and the measurement after two hours was 39.3±3 mm Hg, resulting in a systolic pressure of 162.4 mm Hg.

Such changes in the upper limit of blood pressure may be explained by the presence of a stimulating component—caffeine—in the beverages. The amount of caffeine stated on the packaging of the energy drinks and in the reference beverage (30 mg/100 cm^3) contributes to an increase in blood pressure, maintaining that elevation for two hours.

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In the examined participants of the 1st, 2nd, and 3rd groups, an increased pulse rate was observed. In the 1st group, the pulse frequency rose by 59 beats/min, in the 2nd group by 43 beats/min, and in the 3rd group by 40 beats/min. The highest pulse rate (144 beats/min) was noted among participants consuming Red Bull. According to available data, such a pulse frequency is characteristic of individuals in a state of illness [9].

In the 4th group (placebo), the pulse rate remained virtually unchanged. In contrast, following the consumption of energy drinks, a statistically significant increase in systolic blood pressure and pulse rate was noted within the first 15 minutes. Elevated blood pressure and increased pulse were observed for two hours. The stimulating effect from the consumption of beverages containing 30 mg/100 cm^3 of caffeine was evident throughout this two-hour period.

After assessing the duration of the stimulating effect, participants were given a week of rest to return to their baseline status. Subsequently, tests were administered to determine the intensity of the stimulating effect. Testing was conducted before beverage consumption, five minutes after, and then every hour for three hours during the intake period.

The analysis of the Burdon test results showed that in all groups, the number of characters viewed increased over the two-hour period. After three hours, some participants in the 1st and 2nd groups viewed fewer characters and reported mild fatigue. In contrast, the 3rd and 4th groups exhibited an increase in the number of characters viewed even after three hours of testing.

In all four groups, an increase in the number of correctly crossed-out letters was observed during the first hour. After two hours, this trend continued in all groups except for the one consuming Red Bull. By the three-hour mark, the number of correctly crossed-out letters decreased in the groups consuming energy drinks and the reference beverage. Conversely, in the placebo group, this indicator increased.

The validity of the results ($p < 0.001$) was characteristic of the 1st and 2nd groups after three hours of consuming the specialized product. The number of correctly crossed-out letters was 110.67±14.07 for the 1st group and 100.30±5.35 for the 2nd group. A significant result ($p < 0.001$) was noted in the 1st group for accuracy after two hours (0.95±0.04) and three hours (0.95±0.04). In the 2nd group, accuracy was 0.90±0.03 after two hours and 0.90±0.03 after three hours. In the 4th group, accuracy after two hours was 0.99±0.03.

The results of the calculations in all four groups indicate a minimal number of errors made. The lowest performance success across all groups was observed in the first five minutes

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of the experiment. For the 1st, 2nd, and 4th groups, the success rate ranged from 84.2% to 85.1%. A high success rate of 90.7% to 91.6% was recorded after three hours, with the number of characters viewed being 2946.60±281.35 in the 4th group. In the 3rd group, the number of characters viewed was 2816.93±444.47.

The effectiveness of work was assessed on a 5-point scale based on the time taken to complete the task—less than 30 seconds. The lowest effectiveness was observed in the 3rd group, which received a score of 4 points, while the 4th group completed the task with a score of 3 points.

The degree of acclimatization indicates the need for additional preparation to complete the task. Participants in the 4th group required additional preparation, with a degree of acclimatization of 1.10±0.04. In contrast, the 1st and 2nd groups did not require additional preparation, with acclimatization degrees of 0.91±0.09 and 0.90±0.10, respectively.

Participants in the placebo group were found to be psychologically stable, with a mental stability score of 0.90±0.06. In contrast, participants in the groups consuming energy drinks were deemed psychologically unstable for task completion, with scores of 1.10±0.06 for the 1st group and 1.10±0.08 for the 2nd group.

Throughout the study period, the 1st and 2nd groups exhibited high productivity, requiring less time to engage in the task. However, there was also a noted psychological instability regarding task completion. Overall, the work proceeded relatively efficiently.

The analysis of the obtained data allows us to conclude that the duration of the stimulating effect of energy drinks Red Bull and Burn is approximately two hours. During this period, members of the groups consuming energy drinks exhibited increases in systolic and diastolic blood pressure, as well as pulse rate. Participants in these groups differed from the placebo group by demonstrating heightened attention and productivity. Notable characteristics included rapid engagement in the task and work efficiency, indicating an increase in mental and physical load.However, participants consuming energy drinks exhibited psychological instability while completing tasks. Some reported a deterioration in their well-being after consumption, experiencing symptoms such as physical weakness, throbbing in the temples, and nausea. During the step test, some volunteers expressed a desire to stop consuming the beverage. All of this indicates the need for further research aimed at evaluating both the effectiveness and safety of NAEDs.

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