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Кардиомониторинг волонтеров для установления влияния солодовых экстрактов на уровень физического и психоэмоционального состояния

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Исследовано влияние порошкообразного гречишного солодового экстракта на адаптационные возможности организма, показатели вегетативной и центральной регуляции, уровень энергетического обеспечения организма, психоэмоциональное состояние. Исследования проводили с применением профессионального медицинского диагностического оборудования (комплекс Омега-2М). Установили, что десятидневный курс употребления напитка с вероятностью 99,99% приводит к улучшению показателей кардиомониторинга, улучшение составляет не менее 15% с вероятностью 97,2%. Наблюдается улучшение показателя *Health* (интегральный показатель состояния) после курса приема напитка, если его начальный показатель (частот сердечных сокращений) не превышает 0,76. Если частота сердечных сокращений испытуемого заключена в диапазоне 71–87 ударов в минуту, то курс приема напитка приводит к улучшению показателей интегральный показатель состояния и частот сердечных сокращений.

Ключевые слова: солод, экстракт гречишного солода, сухая смесь, функциональное питание, пищевые ингредиенты, влияние на организм, медицинские показатели

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Cardio Monitoring to Find the Effect of Malt Extracts on the Physical and Psycho-Emotional State of Body

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The influence of powdery buckwheat malt extract based beverages on the adaptive capacity of the body, indicators of vegetative and central regulation, the level of energy supply to the body, the psycho-emotional state is studied. The research was carried out with medical diagnostic equipment (Omega-2M complex). It was found that a ten-day course of beverages consumption with a 99.99% chance leads to an improvement in cardiac monitoring, with an improvement of at least 15% with a 97.2% chance. There is an improvement in the *Health* index (an integral indicator of health status) after the course of beverages consumption if its first indicator (heart rate) does not exceed 0.76. If the heart rate of the subject is between 71-87 beats per minute, the course of beverages consumption leads to an improvement in the integral index of health status and heart rate.

Keywords: malt, buckwheat malt extract, dry mix, functional nutrition, food ingredients, effect on the body, medical indicators

Introduction

The basis of cardiac monitoring technology is discreteness of processes occurring in the human central nervous system in response to various environmental and internal factors (Monge García, Santos, 2019; Lin, Chou, Tsai, Chang, Yang, Ting, Chen, 2018; Ortiz, Davalos, Eusebio, Tucay, 2018; Vanan, Balamurugan, Harish, Nandini, Reddy, 2018; Saugel, Cecconi, Hajjar, 2019; Freitag, Taylor, Wick, Cunningham, Alexy, 2019; Kerstens, Wijnberge, Geerts, Vlaar, Veelo, 2018); "Omega-2M" is applied in medical diagnostics for neurodynamic analysis of the human body heart rate. A characteristic feature of the Omega-2M is nonspecificity to nosological forms of pathology and high sensitivity to a wide variety of internal and external influences.

Two forms of representation of measurement results were used:

1. Visual form allows to estimate qualitative changes in the parameter at once.
2. Numerical form allows receiving exact values of the basic indicators of health status.

Forms make it possible to carry out a quick, correct and objective control of the testers condition before and after beverages consumption.

The purpose of the experiments was to study the influence of beverages consumption on the adaptive abilities of a person, indicators of the nervous system, the energy reserves of the human body, psycho-emotional state of a person. The beverages contained dry powdered malt extracts (Srikaeo, 2020; Garzón, Drago, 2018; Sarabandi, Mahounk, Mohammadi, Akbarbagloo, 2018; Novikova, Agafonov, Korotkikh, Kalaev, Nechaeva, Maltseva, 2016).

Materials and Methods

Powdered dry mixtures beverages

The main ingredient was buckwheat malt powder extract (BMPE). The extract is soluble in water (Танашкина, Семенюта, Троценко, Клыков, 2017; Новикова, Антипова, Агафонов, Коротких, Коростелев, 2018). Dry beverages were packed in 50 g bags for use by testers.

The nutrition values of the BMPE (g in 100 g): Carbohydrates 79.1, Proteins 11.73, Organic acids 1.9. Energy value (kcal in 100 g.) is 368.1 (Starowicz, Koutsidis, Zieliński, 2018; Chen, Huang, Hu, Yan, Ma, 2019; Dzah, Duan, Zhang, Golly, Ma, 2019; Ikeda, Ishida, Ikeda, Asami, Lin, 2017; Коротких, Агафонов, Новикова, 2015).

Omega-2M complex

The research was carried out with medical diagnostic equipment, which allows us to carry out cardio monitoring of the physical and psycho-emotional state of the subjects in real-time in the conditions of the Voronezh State University of Engineering Technologies medical station.

Testers

The results of the survey of 25 testers were used as the object for solving the set tasks. Healthy testers with no severe pathologies, metabolic disorders in the body took part in the study. The mean age of the testing group was 20-21 years, its gender distribution: 14 women, 11 men.

The study was conducted through two stages. At the first stage, the initial assessment of the studied indicators was carried out with Omega-2M complex. In the second stage, the study was carried out after systematic beverages consumption, in the same conditions with the help of an instructor. All the testers signed an told consent to carry out diagnostic manipulations in the form of cardiological examination, and the systematic intake of beverages. The criteria to include healthy persons were: age and sex. The criteria for excluding healthy persons were chronic or acute diseases. Questionnaires of testers and told voluntary consent are given in the primary research materials.

The beverages were prepared by dissolving and mixed in water (200 ml, 25-30°C). Beverages were given to testers daily for 10 days.

The following indicators were recorded by Omega-2M complex: A – level of adaptation of the organism; B – index of vegetative regulation; C – index of central regulation; D – psycho-emotional state; *Health* – integral index of health status; *Heart Rate* – heart rate, norm 60-90; IVB – index of vegetative balance, norm 35-145; VIR – vegetative index of rhythm, norm 0.25-0.604; IAPR – index of adequacy of regulation, norm 15-50; IT – index of tension, norm 10-100.

The information was displayed on a Omega-2M monitor, the results of the cardiological study were presented in the numerical form before and after beverages consumption.

Statistical analysis

The average values of indicators and standard error of measurements were calculated. The significance of the differences between the data were tested using the Mann-Whitney criterion (Afifi, May, Donatello, Clark, 2019).

Results and Discussion

The results of the calculations are presented in Table 1.

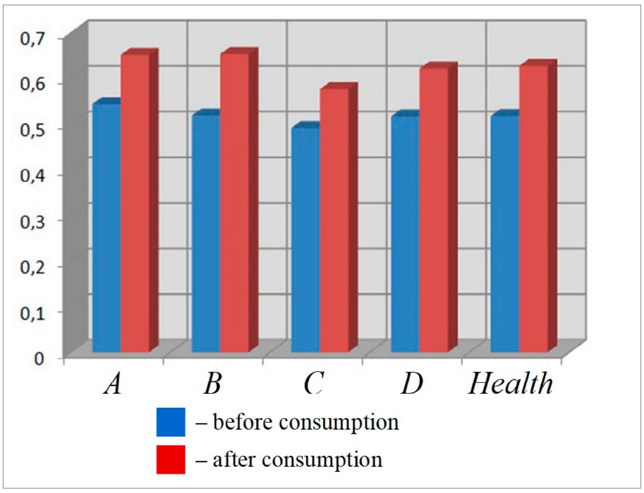
The results of changes in the cardiac monitoring of subjects after a ten-day course of beverages consumption are shown in Figure 1. The arrows show the required direction for improvement of the indicators.

To assess the overall consumption effect, a sample of effect values for each of the E_i indicators was analysed. As a result, the following sample of 10 values was prepared for the analysis (in per cent): 20.3; 25.0; 18.4; 19.2; 19.2; 6.4; 24.2; 15.8; 22.6; 26.5.

A preliminary check was made to make sure the sample distribution law is close to normal using the Student criterion. The average consumption effect is 19.8 ± 1.8%. The standard deviation is σ = 5.75%.

The reliability of the consumption effect was determined by using Student criterion.

The number of degrees of freedom is $N = 10 - 1 = 9$. Two statistical hypotheses were tested. The first hypothesis is “There’s an effect from beverages consumption”. Here $E_{av} = 19.8\%$; $E_0 = 0\%$:



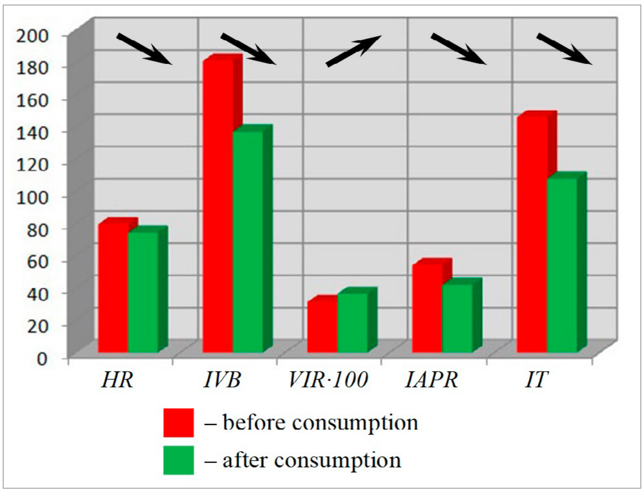


Figure 1. Cardiac Monitoring Indicators.

Table 1
Summary table of test results

Indicator	Before consumption	After consumption	Effect value	Confidence level
A*	0.544 ± 0.037	0.652 ± 0.033	20.3%	96.9%
B	0.519 ± 0.042	0.654 ± 0.040	25.0%	98.6%
C	0.492 ± 0.034	0.577 ± 0.033	18.4%	93.6%
D	0.517 ± 0.037	0.622 ± 0.030	19.2%	95.0%
Health	0.518 ± 0.034	0.628 ± 0.030	19.2%	97.4%
Heart Rate	79.52 ± 1.92	74.43 ± 3.55	6.4%	78.6%
IVB	180.9 ± 29.9	137.1 ± 17.2	24.2%	53.9%
VIR	0.314 ± 0.024	0.364 ± 0.019	15.8%	93.9%
IAPR	54.24 ± 3.94	42.00 ± 3.39	22.6%	99.8%
IT	146.0 ± 22.7	107.9 ± 16.3	26.5%	92.1%

rows with a confidence level greater than 90% are darkened
*bold results are those with a significant level greater than 95%

$$t = \frac{E_{av} - E_0}{s/\sqrt{N}} = \frac{19.8}{5.75/\sqrt{9}} = 10.33 \, , \quad (1)$$

This value exceeds the tabular value of the Student criterion for the number of degrees of freedom N = 9 and the significance level α = 0.001: t (9; 0.001) = 4.78, so, it can be argued there is a consumption effect with a confidence of 99.9%. The significance level for t = 10.33 was also determined. The value α = 0.000002 is obtained.

Thus, beverages consumption for 10 days leads to an improvement in cardiac monitoring indicators with statistical reliability of 99.9998%.

Second statistical hypothesis: "The effect of a ten-day beverages consumption exceeds 15%". Here, Student criterion is:

$$t = \frac{E_{av} - E_0}{s/\sqrt{N}} = \frac{19.8 - 15}{5.75/\sqrt{9}} = 2.50 \, , \quad (2)$$

The significance level for $t = 2.50$ and $N = 9$ is α = 0.0279.

Thus, it is possible to say with a chance of 97.2% that ten-day consumption leads to an improvement in cardiac monitoring by at least 15%.

Improvements in the initial cardiac monitoring of testers were predicted. The most significant indicators among those analysed are *Heart Rate* and *Health*. They express health status and have an integral generalised character. Methods of determination for them are reliable and reasonable (Лосик, Байрамова, Покушалов, Михеенко, Шабанов, Романов, 2017; Полиданов, Блохин, Поздняков, Тупикин, Щербакова, 2020; Сенько, Чучупал, Докукин, 2017; Щербакова, Горохов, Гаффаров, 2016).

The forecasting task is presented in Figure 2. Predicting the *Health* indicator is shown in Figure 3.

*Figure 3***.** Prediction of cardiac monitoring indicators: (a) Prediction of *Health* after a course of consumption; (b) Prediction of *Heart Rate* after a course of consumption; (c) Prediction of the *Health* after the course of consumption according to the initial *HR1*.

Based on approximating of clinical trials data by the method of the least squares the following formula for forecasting in the form of a polynomial of the second order was received:

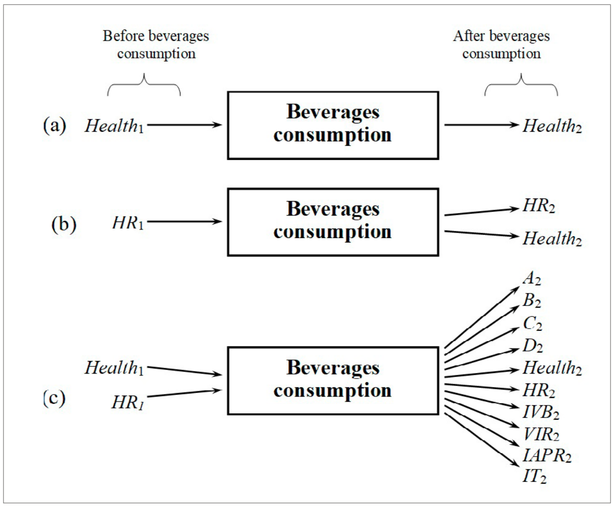


Figure 2. Statement of the forecasting problem: (a), (b) – one-factor forecasting; (c) – two-factor forecasting.

$$Healt_2(Health_1) = -0.93 \times (Health_1)^2 + 1.64 \times \times Health_1 + 005 \, , \quad (3)$$

The dashed line set by *Health1* = *Health2 is* the line that keeps the *Health* indicator. If the value of the *Health* indicator for the test taker is above the line in the Figure, then beverages consumption has a good effect on health. As seen from the graph, most points are above the dashed line, which shows the main improvement of the *Health* indicator. Figure 3*b* shows a graph for predicting *Heart Rate* after beverages consumption. There is an interval of *HR1* values at which the *HR* improves.

$$HR_2(HR_1) = 0.036 \times (HR_1)^2 - 5.12 \times HR_1 + 251 \, , \quad (4)$$

The *Health* is predicted based on the initial *HR1* value after consumption. The result of the prediction is shown in Figure 3. The figure shows the HR_1 at which *Health* is above 0.6.

$$Health_2(HR_1) = -0.00064 \times (HR_1)^2 + 0.0096 \times \times HR_1 - 2.91 \, , \quad (5)$$

From the viewpoint of the optimisation theory (Afifi, May, Donatello, Clark, 2019), it is necessary to determine cases when functions will reach extremes (for two variables):

$$\begin{cases} \Delta Health\left(Health_1, HR_1\right) \to \max; \\ \Delta HRH\left(Health_1, HR_1\right) \to \min, \end{cases} \quad (6)$$

A detailed analysis of the factor space (*Health1*, *HR1*) allowed us to find the areas of factor space that guarantee the highest efficiency of the beverages consumption. These relationships between the input and output parameters can be based on the results of clinical trials (Table 2).

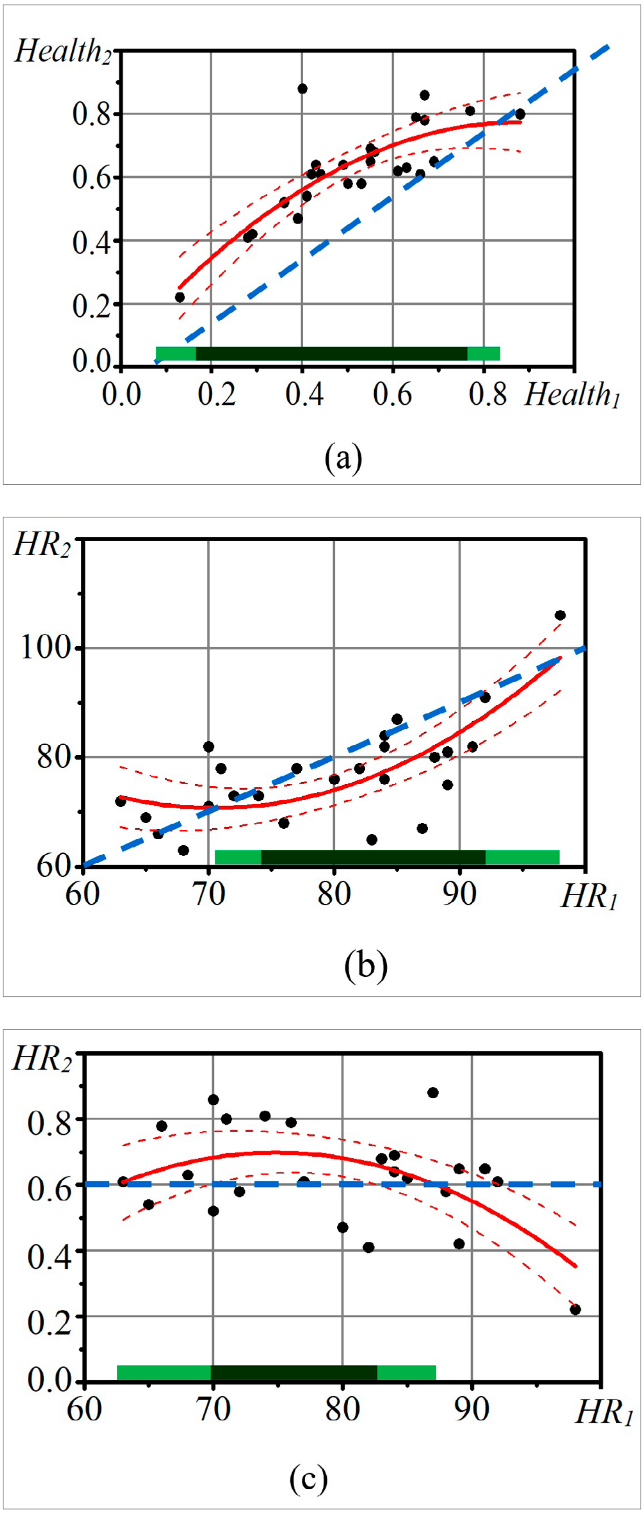


Figure 3. Prediction of cardiac monitoring indicators: (a) Prediction of Health after a course of consumption; (b) Prediction of Heart Rate after a course of consumption; (c) Prediction of the Health after the course of consumption according to the initial HR1.

The task of forecasting was solved by the method of approximation of statistical data by analytical functions and a further search of extrema:

Δ*Health* (*Health1*, *HR1*) and Δ*HR1* were found in the form of second order polynomials:

$$F(Health_1, HR_1) = a_1 Health_1^2 + a_2 HR_1^2 + a_3 Health_1 \times HR_1 + a_4 Health_1 + a_5 HR_1 + a_6, \quad (7)$$

where F is the forecast indicator (Δ*Health* or Δ*HR*); a_1 to a_6 are polynomial coefficients.

To find the coefficients of dependencies F (*Health1*, *HR1*) approximation by the least square method was used. The method comprises solving the inverse problem to find out coefficients a_1 to a_6, at which the total quadratic deviation of the analytical dependence on statistical data will be minimal:

$$\sum_{i=1}^{N}\left(F^{\exp}\left(Health_{1i}, HR_{1i}\right) - F_i^{stat}\left(Health_{1i}, HR_{1i}\right)\right)^2 \to \min, \quad (8)$$

where i is the subject number; N is the total number of subjects; $F^{\exp}$ is analytical dependence of F index on input parameters; F^{stat} is table F values for the i test subject.

Approximation by the least square method was carried out using MathCAD v. 14 (PTC Inc.), resulting in the following formulas for the forecast:

$$\Delta Health(Health_1, HR_1) = -1.627 Health_1^2 - 2.325\times10^{-4} HR_1^2 - 0.025 Health_1 \times HR_1 + 3.359 Health_1 + 0.048 HR_1 - 2.440;, \quad (9)$$

$$\Delta HRH(Health_1, HR_1) = 131.8 Health_1^2 + 0.023\times10^{-4} HR_1^2 + 1.745 Health_1 \times HR_1 - 282.3 Health_1 - 4.909 HR_1 - 279.2;, \quad (10)$$

Surface diagrams are plotted to predict improvements in cardiac monitoring (Figures 4-5).

According to the results of the forecast, it can be noted the tester has an improvement in the *Health* indicator after the course of beverages consumption if its initial indicator of *Health1* does not exceed 0.76. If the *Heart Rate1* is between 71-87 beats per minute, the course of beverages consumption leads to improvement of *Health* and *Heart Rate*. If *Heart Rate* is less than 71, no beverages consumption is required. If *Heart Rate* is greater than 87, other therapeutic and preventive measures should be taken (Sahoo, Thakkar, Lin, Chang, Lee, 2018; Taebi, Bomar, Sandler, Mansy, 2018).

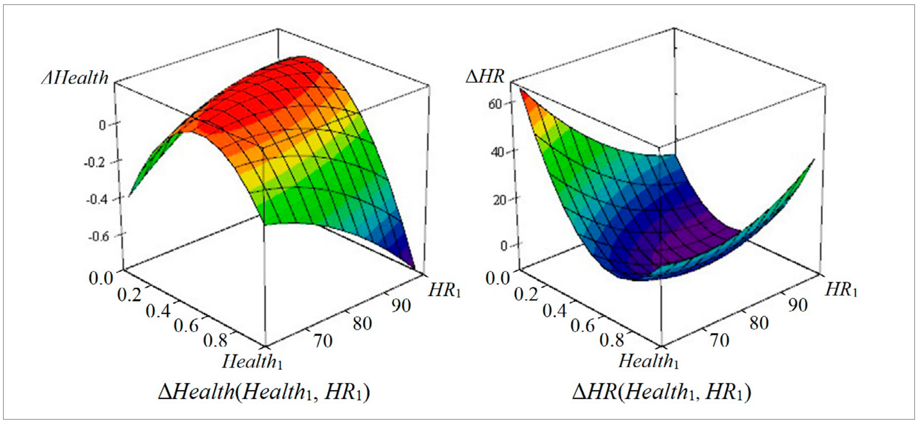


Figure 4. Surfaces for predicting improved cardiac monitoring performance.

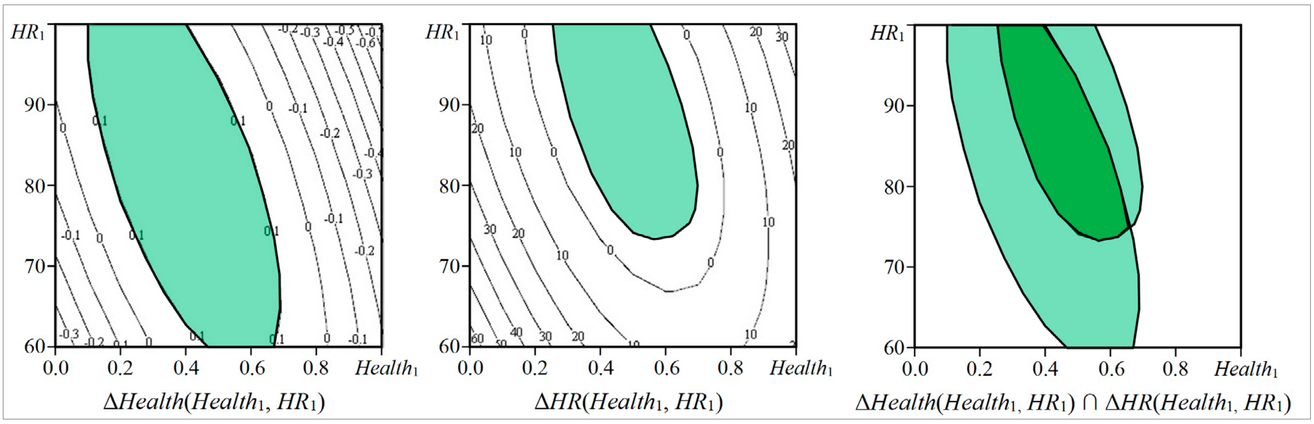


Figure 5. Nomograms of improvement in cardiac monitoring forecasting.

Conclusion

Beverage based on powdered ingredients are developed. Malt buckwheat extract is the basis for beverages. They can be included in the group of mass consumption products and used in everyday diet. They can also be included in the group of food products with known chemical composition and properties. Beverages have a good effect on the physiological functions of the human body. This effect is confirmed in our work with the help of cardiac monitoring indicators.

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