The Elaboration of the Technology of Polymalt Beverages Recommended to the Population of Kemerovo Region Under the Conditions of Negative Ecological Environment

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Abstract. The strained ecological situation in the whole world to a greater or lesser degree concerns the regions of Russia, including Kemerovo region. High level of this region’s industry (mines, coal strip mines, metallurgical plants, etc.) adversely impacts the atmospheric air first of all. According to the official data of Federal State Statistics Service the total pollutant emission into the atmosphere in 2017 exceeded the previous year by 9% in the same parameter, the exceeding of pollutants in the atmosphere concerns to a greater extent soot (carbon), nitrogen dioxide and carbon oxide. With the purpose of civil protection from dangerous effect of bad atmospheric air the bodies of authority take measures oriented to reducing of atmospheric emissions, meanwhile, every separate inhabitant should regulate his/her way of life individually and in such manner as to increase reinforce the immune system and body resistance to external nuisances. One of indispensable aspects which form a healthy lifestyle is a sensible nutrition. In the project there is represented the technology of natural grain beverages on the base of oat, soya, wheat and barley malts, possessing high concentration of protein, amino acids, vitamins and phenol compounds. There have been elaborated four receipts of beverages that are characterized by proportional composition of raw materials being used. The represented technology allows receiving beverages with high nutritious value owing to the content of strong concentration of nitrogen compounds and polyphenol substances allowing to suppress the influence of free radicals on organism and to remove heavy metals thus protecting human organism from aggressive environmental effect.

Introduction

Global ecological problems that annually become apparent in a greater extent and have a ruinous effect on human health and quality of life are undoubtedly of current importance for Russia as well [1-3]. The primary factor that provides with the range of ecological catastrophes is a human being and his aggressive influence on the environment. To the different extents of catastrophe rate this problem concerns all the regions of the country. Still, some regions which are remarkable for highly developed industrial production are being extremely sensitive to the ecological situation, resulting in frequent health damage and dangerous or fatal diseases of the population, and in this connection in low life expectancy. Unfortunately, Kemerovo Region refers to such areas.

According to the official data that is given in the report “The Condition and Protection of Kemerovo Region Environment in 2017” the key factor of ecological situation in this area is the atmosphere air, its chemical composition, and pollution level. The territorial authority of Federal State Statistics Service of Kemerovo Region in cooperation with Federal Service for Supervision in the Sphere of Natural Resource Use represent downward trend on the separate objects of analysis according to the results of 2017. Thus, the total volume of pollutant emissions into the atmosphere exceeded this figure in 2016 by 9.0 %. Herewith, the distribution of emissions in populated localities of the region is not equivalent and it mainly concerns cities including the Region centre and big cities like Novokuznetsk, Leninsk-Kuznetskiy, Prokopyevsk, Belovo, Mezhdurechensk, and others as well.
According to the data of the Centre of Hydrometeorology and Environmental Monitoring (the subsidiary of the Federal State Budgetary Institution “West Siberian Department of Hydrometeorology and Environmental Monitoring”) the atmosphere air of Kuznetsk Basin cities is analyzed for the following substances content: ammonia, soot (carbon), nitrogen dioxide, carbon oxide, suspended matters, aniline, phenol, formaldehyde and hydrogen chloride. And using three cities of Kuzbass (Kemerovo, Novokuznetsk, Prokopievsk) as an example there has been registered an excess of mentioned above compounds on the average in 5 to 82 analyzed samples (about 1), at the same time most of the samples with MAC deviation are registered in soot (carbon) and least in phenol and hydrogen chloride content.

For the purpose of protecting the population of Kuzbass from the dangerous effect of atmospheric air and reducing the negative influence on the environment the state authorities work out legal fundamentals and terms and realize the control of these requirements execution. For today the basic legal documents in the sphere of ecological safety are the Federal Acts: № 7 Federal Act “On Environment Protection” of 10.01.2002 and №96-Federal Act “On Atmospheric Air Protection” of 04.05.1999, there are also the Resolutions of Administration Board of Kemerovo Region № 534 “The Standard Operating Procedures on Harmful (Contaminating) Substances Emission Regulation during the Periods of Unfavorable Weather Conditions on the Territory of Kemerovo Region” of 03.12.2012 and № 362 “On the Approval of Government Program in Kemerovo Region – Ecology, Subsurface Management and Water Conservation – for the period of 2017 – 2021” of 16.09.2016. However, all the given above examples, offered by the federal and regional authorities, do not guarantee the total ecological safety of the population exposed to risk. In this case each person should control his/her living independently.

The contemporary approach to the lifestyle modeling and realization is performed by means of taking the set of measures aimed at strengthening of human organism, its supporting in physical and mental stresses and stresses connected with work, increasing resistibility and endurance and also at the resistance to the effect of negative ecological situation [4-6]. One of the most important factors that provides the achievement of the given above varieties of healthy living is sensible nutrition. Sensible nutrition in the context of contemporary ecological situation including the conditions of intense air pollution with dangerous chemical substances contributes to the solution of a vital task – to oppose the accumulation of dangerous compounds in the human organism and to reduce their adverse effects as much as possible which increases barrier functions of organism as a whole.

The theme that is especially on the front burner is nutrition for people living in an urban setting and constantly undergoing the exposure of heavy metals, specific gases and other chemical substances containing in the atmosphere, as in the case of the cities of Kemerovo Region. People experiencing the entire “negative range” of the environment on the one hand and various overstrains on the other hand, should get special, healthful and dietary, functional food oriented to the improving of separate organs functioning. In the view of most scientists connected with medicine, this type of nutrition must meet certain requirements and include all the essential macro- and micronutrients. First of all, sensible nutrition is to provide the incoming of necessary vitamins, including ascorbic acid, vitamin A and vitamin B complex, choline, that have high biological potency into the human organism. In addition to it, the functionality of food can be proved by the content of aminoacids, and particularly cysteine, methionine, tyrosine, phenylalanine, tryptophane. In some cases (higher risk of incoming heavy metals, radioactive compounds and other highly-toxic substances into the organism) it is recommended to take regularly healthful and dietary food, enriched with pectin substances, containing methoxile groups and polyphenol compounds possessing sorption properties which helps to remove dangerous substances out of the organism.

Nowadays the existing nutrition technologies [7-10] aimed at the working out of specially targeted foodstuffs use in their receipts raw stuff that is notable for higher content of compounds actual for functional food including vegetables, berries, grain raw materials, dairy foods [11-15]. Grain resource, being one of the full-value sources of nutrients essential for a human including vitamin B complex, amino acids and other bioactive compounds is used in the high-priority food technologies connected with foods production such as beverages that are key in human nutrition. We demonstrate the
opportunity to produce polymalt fermented beverages on the base of grain ingredients that are notable for nitrogen compounds content.

The purpose of the research was the elaboration of the technology of functional fermented beverages on the base of oat, soya, wheat and barley malt, which regular usage permits to reduce the risk of dangerous diseases determined by the negative ecological situation in Kemerovo Region.

The research subject was fermented malt beverages; the research materials were oat, soya, wheat and barley malts. The safety and quality evaluation was carried out against the compliance with the requirements of Technical Regulations of the Customs Union, TRCU 021/2011 «On the safety of food products” and All-Union State Standard 31494-2012 “Rye beers. General technical specifications” with the help of traditional methods accepted in beer and soft drinks production and with the help of specific methods of determining vitamins, organic acids, amino acids, microbiological parameters as well.

Results and discussion

Fermented beverages technology was based on the application of grain raw materials notable for high concentration of high- and low-molecular nitrogen compounds, vitamins, phenol compounds.

Organoleptic and physicochemical parameters of the used raw materials are given in Table 1. The content of amino acids, vitamins, polyphenol substances are in Table 2.

Table 1 - Malts quality parameters

| Parameter name                        | Content in malt                      |
|---------------------------------------|--------------------------------------|
|                                       | oat   | soya   | wheat | barley |
| Appearance                            |       |        |       |        |
| Color                                 | peculiar to the given type of malt, without foreign flavor and smell shadows |
| Smell                                 |       |        |       |        |
| Taste                                 | 6.0±0.1 | 4.0±0.1 | 5.9±0.1 | 5.8±0.1 |
| Moisture content, %                   | 62.3±0.1 | 62.4±0.1 | 68.2±0.1 | 78.5±0.1 |
| Extract content in dried malt, %      |       |        |       |        |
| Protein content, %                    | 13.2±0.1 | 33.8±0.1 | 7.8±0.1 | 11.0±0.1 |
| Starch content, %                     | 49.2±0.5 | 22.8±0.5 | 57.5±0.5 | 52.1±0.5 |
| Fat content, %                        | 2.2±0.1 | 8.7±0.1 | 1.8±0.1 | 1.9±0.1 |
| Saccharification duration, min        | 20±1  | -     | 20±1  | 13±1   |
| Amylolytic activity, u/g              | 196.0±0.1 | 132.5±0.1 | 273.2±0.1 | 350.5±0.1 |
| Proteolytic activity, u/g             | 32.4±0.1 | 76.4±0.1 | 152.3±0.1 | 60.5±0.1 |
| Cytological activity, u/g             | 345.1±0.1 | -     | 84.6±0.1 | 69.1±0.1 |
| Urease activity, u. pH                | 0.4±0.01 | -     | -     | -      |
| Laboratory mash wart:                 |       |        |       |        |
| Color, cm² of iodine solution with concentration 0,1 mole/dm³ per 100 cm² of water | 0.12±0.01 | 0.09±0.01 | 0.12±0.01 | 0.15±0.01 |
| Acidity, cm² of sodium hydroxide solution with concentration of 1 mole/dm³ per 100 cm² of mash wart | 1.4±0.01 | 1.1±0.01 | 1.1±0.01 | 1.0±0.01 |
| Transparency                          | transparent | transparent | sufficiently transparent | Transparent |
The results represented in the Tables reflect the filling of the malted grain products used in the research with the essential bioactive compounds: vitamins, amino acids and polyphenol compounds that facilitate to suppress the activity of free radicals, to fulfill barrier functions and to remove heavy metals and other perverse effects of the environment aggressive influence by means of complex compounds formation from human organism. Also the represented data allows to assess the feasibility of suggested malts usage from the technological point of view in the fermented polymalt beverages production. barley and wheat malts are characterized by high amylolytic activity, and in addition the wheat malt is noted for proteolytic activity that guarantee full-fledged hydrolysis of starch polysaccharides and nitrogenous compounds with various molecular numbers of grain raw materials on the stage of mash wart preparation. Oat malt has high cytologic activity which allows to conduct splitting of non-starch polysaccharides and to reduce the viscosity of mash wart. The critical values of non-traditional soya malt are firstly “fat content, %”, which is on the quite high level relational to other raw materials, at which point the application of this grain component should be slightly limited.

### Table 2 – Content of amino acids, vitamins, phenol compounds in study samples of malt (n=5)

| Nutrient name                                      | Content in malt          | Oat | soya | wheat | Barley |
|----------------------------------------------------|--------------------------|-----|------|-------|--------|
| **Amino acid content in a sample, mg/100g of product dry substance.** |                          |     |      |       |        |
| Alanine                                            | 450                      | 2360| 410  | 400   |        |
| Arginine                                           | 760                      | 3270| 660  | 580   |        |
| Valine                                             | 640                      | 1780| 320  | 680   |        |
| Histidine                                          | 300                      | 1320| under 200 | 250  |
| Glycine                                            | 460                      | 2120| 350  | 410   |        |
| Lysine                                             | 410                      | 2920| 290  | 290   |        |
| Asparagine and asparagic acid                      | 890                      | 7460| 760  | 950   |        |
| Glutamine and glutamic acid (total)                | 3120                     | 9840| 3260 | 3460  |        |
| Leicine and izoleucine                             | 850                      | 5090| 910  | 960   |        |
| Triptophane                                        | 850                      | 3220| 320  | 360   |        |
| Methionine                                         | 350                      | 600 | under 200 | under 200 |
| Proline                                            | 1520                     | 2480| 950  | 1620  |        |
| Serine                                             | 430                      | 3110| 500  | 260   |        |
| Tyrosine                                           | 490                      | 1570| 230  | 230   |        |
| Threonine                                          | 670                      | 2380| 380  | 390   |        |
| Xenylamine                                         | 340                      | 2180| 360  | 360   |        |
| Cystine                                            | 410                      | 1100| 410  | 260   |        |
| Total                                              | 12390                    | 50110| 10390| 11500 |        |
| **Vitamin content, mg/100g of product dry substance.** |                          |     |      |       |        |
| Vitamin B₁                                         | 0.49                     | 0.98| 0.46 | 0.33  |        |
| Vitamin B₂                                         | 0.13                     | 0.21| 0.17 | 0.16  |        |
| Vitamin PP                                         | 1.55                     | 2.24| 5.62 | 4.67  |        |
| Vitamin E                                          | 2.90                     | 17.30| 6.47 | 2.81  |        |
| Biotin                                             | 15.0                     | 60.2| 11.8 | 11.2  |        |
| Choline                                            | 109.6                    | 284.1| 90.2 | 104.2 |        |
| Pantothenic acid                                   | 1.00                     | 1.78| 1.08 | 0.60  |        |
| Niacin                                             | 1.52                     | 2.12| 5.62 | 4.41  |        |
| Thiamine                                           | 0.48                     | 0.91| 0.41 | 0.32  |        |
| **Polyphenol compounds content, mg/100g of product dry substance.** |                          |     |      |       |        |
| Phenol compounds in total                          | 350                      | 2080| 450  | 180   |        |
as fat compounds while their transit to the malt mash wart provoke its technical features degradation and thus have a negative impact on the further stages – preparation of malt mash wart and its fermentation. Secondly, “Urease activity, u. pH”, which is on the safe level due to the use of special processing of soya with the complex of organic acids at the stage of malt preparation what allows to use this grain raw materials in the production of beverages.

The beverages technology included the consequent realization of the following stages: preparing of polymalt mash wart, fermenting of mash wart, beverage cooling and clarifying, beverage filling. Preparing of polymalt mash wart was conducted with the use of infusion mashing of grain products with maintaining pauses necessary in mashing for full-value running of hydrolytic processes and saccharifying of mash mass. During production of mash wart there were conducted researches on the influence of separate grain components – alternative raw material – on technological characteristics of the received mash wart and on the behavior of the mashing process at large (duration of saccharifying and mash filtering). At this time there were visually observed mash mass transparency and viscosity, basic physical and chemical parameters of mash wart (dry substances weight content, acidity, maltose and amino nitrogen content) and also the specific factors which deal with colloidal stability of future beverage – concentration of polyphenol and albuminous compounds. The dosage of barley malt varied from 50 to 90 per cent, the dosage of alternative raw material – from 5 to 20 per cent on grain products basis.

In the course of the experiment there was registered that entering alternative malt in the form of wheat malt of high dosage (up to 20 per cent) influenced negatively the mash wart samples even visually while entering oat and soya malts even of maximum norm did not lead to the changes of organoleptic characteristics – color, smell, flavor and transparency were coincident to the characteristics of mash wart prepared on the base of wheat malt only. As to filtration, as in the case of using malt higher than 10 per cent to grain products mass there was also observed the increase of filtration length and the received mash wart was characterized by increased turbidity. The use of oat and soya malts of all the suggested dosages from 5 to 20 per cent appeared similarly during filtration and turbidity of mash wart – it did not deteriorate the given characteristics. With account of the results of the conducted experiment it is rational to suggest the following norms of entering the alternative malts: wheat malt – up to 10 per cent, oat and soya malts – up to 20 per cent (further increase of soya malt part is not desirable in spite of positive results of the conducted experiment in view of high fat content in the raw material which supposed negative effect was not discovered).

In summary taking into account all the results of the conducted experiment there were selected several variants of beverage formulae represented in Table 3.

| Type of used malt | Percent of grain component, % | Beverage 1 | Beverage 2 | Beverage 3 | Beverage 4 |
|-------------------|-------------------------------|------------|------------|------------|------------|
| barley            | 70                            | 70         | 70         | 65         |
| wheat             | 10                            | 10         | 10         | 5          |
| soya              | 20                            | -          | 10         | 15         |
| oat               | -                             | 20         | 10         | 15         |

Grain ingredients represented in the receipts were crushed, mixed with treated water at water duty of 1:4 and there was conducted infusion mashing with maintaining basic necessary pauses according to the order described previously. This method is reasonable as the raw materials existing in the grain mixture are remarkable for high fermentative activity and do not require additional boiling off. Upon completion of mashing the malt wart samples underwent filtration and were sent to fermentation. Fermentation was conducted with the help of “Saf-instant” dry bakery yeast, which were introduced into malt mash wart with the initial extract content of 8 %. Fermentation proceeded at the temperature of 28-30 °C during 18-20 hours at average for all the samples and after its completion the weight content of dry substances went down by 2.4-2.6 %.
The concluding technological operation was cooling and natural clarifying of fermented beverages that proceed at the temperature of 2-4 °C and within the period of 10-12 hours after which there was conducted separation of beverage and sediment with decantation. Ready-made samples underwent physical and chemical analysis for compliance of parameters level with the requirements of the All-Union State Standard 31494-2012 “Rye beers. General technical specifications” and degustation as well. The results of tasting analysis on such parameters as appearance, color, transparency, taste and fragrance, saturation with carbon dioxide showed that all the samples have overall estimate of 18.5-19 points (at maximal scale of 20 points) and correspond to the “excellent” quality.

The estimation of all the developed fermented polymalt beverages upon physical and chemical parameters and safety parameters considered by regulatory documents for the given group of food production was conducted right in the ready-made samples and also upon acidity increase within the period of 10-12 hours after which there was conducted separation of beverage and sediment with decantation. Ready-made samples underwent physical and chemical analysis for compliance of parameters level with the requirements of the All-Union State Standard 31494-2012 “Rye beers. General technical specifications” and degustation as well.

Table 4 – Quality parameters of fermented polymalt beverages (n=5)

| Parameter name                        | Content in the beverage |
|---------------------------------------|-------------------------|
|                                       | 1           | 2           | 3           | 4           |
| **Basic physical and chemical parameters** |            |            |            |
| Weight content of dry substances,%   | 6.7±0.1    | 6.6±0.1    | 6.5±0.1    | 6.5±0.1    |
| Acidity, acid units.                 | 3.70±0.01   | 3.70±0.01   | 3.60±0.01   | 3.60±0.01   |
| Volume content of ethanol, %         | 1.00±0.01   | 1.10±0.01   | 1.2±0.01    | 1.2±0.01    |
| **Secondary fermentation products**  |            |            |            |
| methyl acetate, mg/dm³               | 13.1±0.2    | 12.9±0.2    | 11.7±0.2    | 12.2±0.2    |
| isoamylose acetate, mg/dm³           | 12.8±0.1    | 11.9±0.1    | 11.9±0.1    | 12.7±0.1    |
| acetaldehyde, mg/dm³                 | Traces      |            |            |            |
| isoamyl alcohol, mg/dm³              | 49.3±0.2    | 50.8±0.2    | 47.8±0.2    | 49.0±0.2    |
| isobutyl alcohol, mg/dm³             | 21.5±0.5    | 25.1±0.5    | 23.4±0.5    | 24.1±0.5    |
| propyl alcohol, mg/dm³               | 4.2±0.1     | 14.1±0.1    | 11.7±0.1    | 13.1±0.1    |
| methyl alcohol, % vol.               | Not detected |            |            |            |
| **Organic acids, mg/dm³**            |            |            |            |
| Apple                                 | 1380.0±10   | 1390.0±10.0 | 1410.0±10.0 | 1370.0±10.0 |
| Citric                                | 369.0±1.0   | 378.0±1.0   | 400.5±1.0   | 388.0±1.0   |
| Amber                                 | 11.8±0.1    | 11.9±0.1    | 11.4±0.1    | 11.3±0.1    |
| Lactic                                | 12.7±0.2    | 13.0±0.2    | 12.6±0.2    | 11.6±0.2    |
| **Amino acids content, mg/100 cm³**  |            |            |            |
| Essential                             | 3960        | 3170        | 3460        | 3820        |
| Nonessential                         | 7140        | 6720        | 6690        | 7070        |
| Total amino acids                     | 11080       | 9890        | 10150       | 10890       |
| **Vitamins content, mg/100 cm³**     |            |            |            |
| Vitamin B₁                            | 0.14        | 0.12        | 0.13        | 0.15        |
| Vitamin B₂                            | 0.05        | 0.05        | 0.05        | 0.06        |
| Vitamin PP                            | 0.34        | 0.28        | 0.31        | 0.36        |
| Vitamin E                             | 1.52        | 0.38        | 1.12        | 1.61        |
| Biotin                                | 5.27        | 3.14        | 4.12        | 5.35        |
| Choline                               | 34.66       | 25.41       | 30.45       | 34.71       |
Table 5 – Microbiological parameters of fermented polymalt beverages

| Parameter name                                      | Parameter value                                      | in compliance with technical regulations requirements | group of fermented polymalt beverages |
|-----------------------------------------------------|------------------------------------------------------|-------------------------------------------------------|---------------------------------------|
| QMA&OAMO, CFU/1000 cm³, max                          | 10/30                                                 | not detected                                          |                                       |
| Coliform bacteria, product volume cm³, in which it is not admitted | 333                                                  | not detected                                          |                                       |
| Pathogenic, including Salmonella, product volume cm³, which is not allowed | 100                                                  | not detected                                          |                                       |
| Yeast and mold, product volume cm³, which is not allowed | 40                                                   | not detected                                          |                                       |

Conclusion

So the received results fortify the possibility of functional fermented beverages production on the base of malted grain raw materials with increased nutrition value. The ready-made beverages are characterized by high qualitative characteristics, do not contain inadmissible microbial flora and include biologically active components such as vitamins, amino acids, polyphenol compounds that help the human organism to endure dangerous ecological situation. And with the help of varying the correlation of grain raw materials in polymalt mixture there can be achieved the increase of definite organic components in a ready-made product. Besides the applying of the stage of grain malt wort fermentation in the technology make it possible to enrich a ready-made beverage with fermentation products including organic acids what will increase its nutrition value. According to the represented above conclusion it can be recommended to use polymalt fermented beverages for people living in severe ecological conditions, for instance living in Kemerovo Region.

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