Comparative study of micronutrient content in soft rice beverages based on green and black tea

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Abstract. Soft beverages based on rice (“rice milk”) are hypoallergenic, increase immunity, supply the body with energy, and normalize the nervous system. Earlier, we developed soft rice beverage recipes based on boiled rice filtrate, green (black) tea water concentrate, stevia extract as a natural sweetener. Physico-chemical analysis of the content of micronutrients in soft rice-tea beverages was carried out. Comparative analysis of content of vitamins E (alpha-tocopherol) and C (ascorbic acid) showed that vitamins are presented in both types of beverages during production, but in different amounts. The rice beverage combined with green tea concentrate contains 1.33 times more potassium ions and 1.13 times less magnesium ions than the beverage based on black tea. The rice beverage combined with black tea contains 3.81 times more sodium ions compared to the beverage based on green tea. There were no significant differences in the number of magnesium ions. Both samples contained traces of manganese and iron ions. The produced soft rice-tea beverages with stevia extract could be recommended as a functional food.

1 Introduction

Today, claims about the ability of foods and food components to reduce disease risks or enhance the quality of life continue to captivate our lives [1]. Irrational nutrition is a primary factor in unattained genetic potential, reduced physical and cognitive performance, and increased risk of some diseases. Unquestionably, strategies that optimize nutrition by the use of foods or supplements are highly commendable.

The term “functional food” broadly refers to foods with physiologically active components that provide health benefits beyond basic nutrition [2].

Functional foods do not cure or prevent illnesses and are not essential to the diet. Functional foods could be viewed in the context of a healthy diet to exert their potential interest.
Numerous foods are already associated with health promotion and disease prevention. The diversity of these foods suggests a variety of components that can be involved. It has been estimated that there are about 25,000 different chemical compounds in fruits, vegetables and other plants that human eat. To date, more than 500 compounds have been identified as potential modifiers of the cancer process. Both essential and non-essential allelochemicals found in plants, as well as zoocompounds found in animal products, may be physiologically important modifiers of many biological processes. Compounds belonging to such diverse categories as carotenoids, dithiolthiones, flavonoids, glucosinolates, isothiocyanates, allyl sulphhydrils and fermentable fibers have been found to affect various cellular processes that are expected to influence health [3, 4].

Modern life requires products to meet the requirements of a healthy diet. Functional foods are enriched with metabiotics [5], biologically active substances of plant and animal origin, and micronutrients [6]. The use of probiotics and a mixture of rice and pea proteins in a fermented beverage can increase the nutritional and nutraceutical value of the product [7].

In the prevention and treatment of cardiovascular diseases, and overweight, it is important to use fruit and vegetable products, especially in the diet of schoolchildren, the effect of functional vegetable dishes on the daily diet was shown by some authors [8].

One of the new sources of gluten-free raw materials is hemp flour, which has a high nutritional value and, unlike cannabinoid leaves and inflorescences, does not contain the narcotic psychotropic substance cannabinoid. The gluten-free biscuit made of hemp flour are enriched with magnesium, zinc, phosphorus, p-carotene and fat-soluble vitamins [9].

Functional foods are useful for meeting the body's nutritional needs and helping to combat other degenerative diseases associated with today's changing lifestyles.

Benign prostatic hyperplasia (BPH) is a common chronic disease in ageing men. In rats treated with lycopene and iodized whey milk protein, prostate weight and prostatic index were significantly reduced compared with controls, and the combined use of lycopene and iodized whey milk protein had an additive effect [10]. Herbal compounds were suggested as an alternative option for the BPH treatment. The effect of kudzu isoflavones and astaxanthin has been studied on the BPH animal model [11]. The results showed that isoflavones, and especially astaxanthin, can serve as a potential alternative therapy for the treatment of BPH.

Diabetes mellitus is the most common metabolic disease characterized by elevated glucose levels due to defects in insulin secretion, insulin resistance in peripheral tissues, or both [12].

To date, more than 1,200 medicinal plants with antidiabetic activity have been identified. These phytotherapeutic methods are considered safe and cost-effective compared to synthetic therapies [13].

Stevia is one of the wonder-working medicinal plants against many diseases [14, 15]. Stevia contains many important phytochemicals compounds that have properties to reduce blood cholesterol and sugar levels, as well as blood pressure. It can also improve taste and flavor. Rebaudioside A and stevioside are important heat-stable sweetening compounds used as a source for prepared foods [16]. Stevioside is found in the leaves of S. rebaudiana Bertoni and is 300 times sweeter than sucrose [17]. These leaves are also rich in carbohydrates. Rebaudioside A is considered 250-400 times sweeter than sucrose and is used as a food/sweetener [18].

Obesity has recently emerged as a major global health problem. The World Health Organization (WHO) and Scientific Advisory Committee on Nutrition (SACN) recommend a diet where a maximum 5% of the energy comes from free sugars. In the USA, two out of three adults and one out of three children are overweight or obese, and over 18% of children aged 6-19 have body mass index (BMI)>95th percentile [19]. Overweight and
obesity can have major costs for individuals and their families as well as for the health care systems. It increases the risk of developing type 2 diabetes and cardiovascular disease, and doubles the risk of premature death [20].

Type 2 diabetes has also emerged as a global public health concern, parallel to the global trends in the prevalence of obesity. Along with the increased consumption of soft drinks, there has been a rapid and large increase in the reported incidence of type 2 diabetes [21].

Soft drinks include carbonated drinks, still and juice drinks, dilutables, fruit juices, bottled waters, sports and energy drinks [22]. Soft drinks are often high in sugar content and acidity. In addition, they provide only energy and have little nutritional benefit [23, 24]. Several artificial sweeteners are used to give diet soft drinks a sweet, sugar-free taste. Some studies have linked consumption of artificial sweeteners to adverse health conditions, including obesity, lymphoma, leukemia, bladder and brain cancer, chronic fatigue syndrome, Parkinson's disease, Alzheimer's disease, multiple sclerosis, autism, and systemic lupus erythematosus [25].

The consumption of artificial sweeteners has been found to promote weight gain rather than weight loss in several studies [26]. Studies showed that these sweeteners cause insulin production into the blood and in the absence of blood sugar, hypoglycaemia and increased food intake occur resulting in overweight and obesity. The carcinogenic potential of artificial sweeteners, mainly aspartame and saccharine, has been investigated. Exposure to these chemicals was associated with an increased risk of brain tumours and bladder cancer, in both male and female mice, respectively [27, 28]. Conversely, further studies did not conclude a clear causal relationship between consumption of aspartame, saccharin, and other approved artificial sweeteners and human health risks at normal doses [29].

Tea is one of the most common drinks consumed in the world. It is the most popular beverage containing caffeine. Tea is made by brewing the processed leaves of the tea plant *Camellia sinensis*. Tea is used as a stimulating drink.

Tea and tea-based products have become some of the most important beverages around the world and they will continue to grow as part of a healthy lifestyle of consumers. In the past 5 years, significant progress has been made in tea beverage research, including liquid tea beverage, instant tea powder, tea concentrate, kombucha, tea wine and other fermented tea beverages have been used in flavor evaluation of tea beverages [30].

Tea extracts are source of polyphenols, which are antioxidant components. Green tea phenolic compounds are predominately composed of catechin derivatives, although other compounds such as flavonols and phenolic acids are also present in lower proportion. Tea has various pharmacological effects, especially anticancer and antioxidant activity, and could be a powerful tool for future better treatment [31].

The effect of commercially available green tea (GT) and black tea (BT) beverages on drugmetabolizing enzymes (DME) and oxidative stress in rats was studied. Male Wistar rats were fed a laboratory food diet and a GT or BT beverage for 5 weeks. The results obtained showed that consumption of both tea drinks by the rats modulated DME activity and reduced oxidative stress in the liver and lungs. GT drink is more effective in reducing oxidative stress than BT drink [32].

Cardiovascular disease is a chronic multifactorial health complication that is directly or indirectly associated with pathophysiological mechanisms, including pro-oxidation, pro-inflammation, vascular and endothelial dysfunction, impaired platelet function, thrombosis, and others. L. Rajan *et al.* [33] emphasized the possibility of therapeutic variations associated with gene polymorphisms in individuals using green tea for cardio-metabolic effects and the need to personalize green tea for clinical use.

Despite concerted efforts to improve diet quality and reduce malnutrition, micronutrient deficiencies remain widespread worldwide, especially in low- and middle-income countries.
and among high-needs population, where iron, zinc, folate, vitamin A, calcium and vitamin B12 are often lacking in the diet [34]. A study was conducted to determine the micronutrient status of tea (Camellia sinensis L.) plantations in the Eastern Black Sea region of Turkey [35]. The determined Fe, Cu, Zn and Mn contents in leaf samples were 86-959, 4.5-73.9, 5.6-46.3 and 141-2767 mg/kg, respectively.

Rice milk is a dairy-free type of milk that is prepared with boiled rice, rice starch, water and syrup. There are no animal byproducts in this milk, making it a very popular option for vegetarians and vegans, having a number of critical nutrients. Furthermore, since it is a dairy-free option, it contains no lactose, so people with lactose intolerance can use it [36, 37]. The rice-derived milk is an ideal alternative not only for vegans and those with lactose intolerance, but it is also a healthy option for other people who want a unique mineral and nutrient boost without taking in much fat or calories. This popular dairy alternative has a wide range of impressive nutrients, including about 140 calories per cup and only about 3 grams of fat -- much less than the 10 grams of fat in a cup of whole cow's milk. This type of milk has no cholesterol, making it much healthier for heart health, and most brands of rice milk are fortified with other minerals. Because cow's milk provides a better set of minerals, rice milk is often supplemented with calcium, B vitamins, iron, vitamin A, and vitamin D to make it roughly equivalent to cow's milk [38].

This work aimed to study the micronutrient composition of soft rice beverages based on green and black tea concentrates with the stevia extract. Assessed were the contents of vitamins C and E, macroelements (potassium, sodium, magnesium), microelements (manganese, iron).

2 Materials and methods

The following materials were used in the study:

- White rice grain (Russia).
- Dried green tea leaves (China, 2019). Made in Zhejiang.
- Dried black tea leaves (China, 2019). Made in Yunnan.
- Drinking water according to Russian State Standard GOST R51232-98 [39].
- Stevia, dry extract (Russia).

The common technology of soft rice beverage production is as follows: rice flour boiling at +180 °C for 15 min→ grinding→ keeping in a constant temperature (+30°C) water bath for 2 hours→ colloid grinding for 3 min → keeping in water bath (+70°C) for 30 min→ filtration→ rice decoction. For the preparation of rice beverages combined with green tea and black tea concentrates, 2.8% water concentrates of green and black tea were added into a filtered rice decoction. The ratio of tea water extract to rice decoction was 4:1. The ratio for soft rice-tea beverage components was calculated using the previously studied beverage organoleptic properties. Stevia extract was added to beverage in the ratio of 1 g:100 ml.

The concentration of vitamin E in tea-rice beverages was determined in accordance with GOST EN 12822-2014 using high-performance liquid chromatograph with a fluorimetric detector (Lumachrom) [40].

The concentration of vitamin C in tea-rice beverages was determined in accordance with GOST 34151-2017 (BS EN 14130:2003) using the high performance liquid chromatograph with a fluorimetric detector (Lumachrom) [41].

The concentration of sodium ions (Na) in tea-rice beverages was determined in accordance with GOST 23268.6-78 using the flame photometer (Jenway PFP 7) [42].

The concentration of potassium ions (K) in tea-rice beverages was determined in accordance with GOST 23268.7-78 using the flame photometer (Jenway PFP 7) [43].
The concentration of magnesium ions (Mg) in tea-rice beverages was determined in accordance with GOST 23268.5-78 using the atomic absorption spectrometer (Perkin Elmer AAanalyst 600) [44].

The concentration of iron ions (Fe) in tea-rice beverages was determined in accordance with GOST 23268.11-78 using the chemical titration method [45].

The concentration of manganese ions (Mn) in tea-rice beverages was determined in accordance with GOST 4974–2014 using the atomic absorption spectrophotometer (Perkin Elmer AAanalyst 600) [46].

All data were reported as the standard error of the mean (SEM). Statistical data processing was made using the GraphPad Prism 6 software (GraphPad Software Inc., La Jolla, USA), and SPSSH Statistics ver. 17.0 (IMB, New York, USA).

3 Results

The comparative analysis of vitamin E (alpha-tocopherol) content in soft rice beverage based on green and black tea, stevia extract, is shown in Figure 1.

![Graph showing vitamin E content in soft rice beverages](image-url)

**Fig. 1.** Vitamin E content in soft rice beverages combined with water concentrates of green tea, black tea and stevia.

The presence of vitamin E was found in both tea-rice beverages.

The comparative analysis of the ascorbic acid content in soft rice beverage based on water concentrates of green and black tea, stevia extract is shown in Figure 2.
Fig. 2. Ascorbic acid content (mg/kg) in soft rice beverages combined with water concentrates of green tea, black tea and stevia.

Fig. 2 shows the presence of ascorbic acid (vitamin C) in both tea-rice beverages. The comparative analysis of macro- and microelement contents in soft rice beverage based on water concentrates of green and black tea, stevia extract is shown in Fig. 3.

Fig. 3. Content of macro- and microelements (mg/kg) in soft rice beverage based on green tea and black tea water concentrate, stevia extract.

4 Discussion

The comparative analysis of the vitamin E (alpha-tocopherol) content in soft rice beverages combined with water concentrates of green tea, black tea and stevia showed that vitamin E is preserved in both types of drinks during production.

Ascorbic acid (vitamin C) is preserved during the preparation of tea-rice beverages of both types. Green tea-based beverage contains 1.2 times more vitamin C than black tea-based beverage.

Numerous studies have examined the relationship between dietary consumption of antioxidants and inflammation. Inflammation and oxidative stress are associated with the development of numerous chronic diseases. Circulating concentrations of ascorbic acid, \( \alpha- \)
tocopherol, and 25-hydroxyvitamin D (25(OH)D), which are considered biomarkers of vitamin C, E, and D nutritional status, may help reduce concentrations of pro-inflammatory cytokines through their antioxidant and anti-inflammatory properties [47].

Data analysis showed that the tea-rice beverage based on green tea contains 1.33 times more potassium ions and 1.13 times less magnesium ions, compared with the black tea-based drink. The tea-rice beverage based on black tea contains 3.81 times more sodium ions compared with the drink based on green tea. Both samples contain traces of manganese and iron ions, with a higher content of manganese ions.

Observational and experimental evidence supports an independent positive association between sodium intake and blood pressure, most clearly seen in populations with hypertension [48]. Dietary electrolytes, such as sodium and potassium, affect blood pressure and may also be associated with cardiovascular disease [49].

Being an essential human dietary element, manganese plays a very important role in human body. It is present as a coenzyme in several biological processes that include macro nutrient metabolism and bone formation. It also has antioxidant properties and provides a defense system against free radicals in the human body. It is an important component of dozens of proteins and enzymes [50].

The rice mash, obtained after tea-rice beverage production, can be used in the further rectification process to obtain new products, ethanol distillate or bioethanol [51].

Thus, regular consumption of tea-rice beverages combined with green (black) tea concentrate and stevia extract can have a beneficial effect on reducing inflammation, regulating the electrolyte balance of the body, normalizing the permeability of the vascular wall, reducing the risk of atherosclerosis, increasing the cellular antioxidant activity of systems to fight free radicals.

5 Conclusions

The comparative physico-chemical analysis of the micronutrient composition of beverages produced according to the newly developed formulation and technology, showed that both types of soft rice beverages based on green (black) tea concentrates and stevia extract contain vitamins C and E, macroelements (potassium, sodium, magnesium), microelements (manganese, iron).

The soft tea-rice beverage combined with green tea concentrate and stevia extract contains 1.2 times more vitamin C, 1.33 times more potassium ions compared to the beverage based on black tea and stevia extract.

Vitamin E, magnesium, manganese, iron are present in equal amounts in both types of soft rice-tea beverages.

The soft rice beverage based on green (black) tea concentrate and stevia extract as a sweetener, could be recommended as a functional food.

References


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