Justification for the use of waste from tea production

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Abstract. In tea-importing countries, to which Russia belongs, waste such as tea dust remains at tea packaging enterprises. This is a powdery mass consisting of particles of dry leaf tea. Leaf tea contains valuable biological compounds: caffeine, flavonoids, tannins, proteins, vitamins. It can be assumed that the chemical composition of tea dust and leaf tea are similar. In order to determine the possibility of rational use of tea dust, a study was conducted of its organoleptic, physico-chemical characteristics and chemical composition. We used an average sample of tea dust, which was compared with black leaf and green leaf tea obtained in one enterprise. Laboratory methods determined the total content of water-soluble extractive substances, the mass fraction of moisture, the total ash content, the content of water-soluble polyphenols, total and non-protein nitrogen, as well as the protein content and the content of various carbohydrates. It was found that the composition of tea dust is dominated by the remains of black tea leaves, which corresponds to the share of this tea variety in the company's products. Tea dust slightly exceeded black leaf tea in extractives - 35.64% (black tea - 32.47%), mass fraction of moisture - 7.45%, total ash content - 6.19%. In the tea dust sample, the content of water-soluble polyphenols was 7.46%, the amount of protein was 17.44%. The bulk of the proteins are insoluble in water. Studies have shown that tea dust has the potential of an additional raw material source of biologically active substances.

1. Introduction
Interest in the integrated rational use of food raw materials increases with the development of processing technologies and the expansion of research in the field of biology and chemistry of plant materials. These trends are also characteristic of the tea industry.

The primary, main, processing of tea raw materials occurs near the places of its cultivation, i.e. in tea producing countries. In the tea importing countries, to which Russia belongs, they sort, mix and package finished products under production conditions.

At this stage, by-products are formed - tea scrap and dust, which are regarded as secondary material resources. If the scrap of leaves can be directed to the production of packaged tea, then tea dust is usually thrown away, therefore, part of the valuable raw materials are lost. It is also important that the disposal of tea dust will improve the environmental status of industrial premises, since a high concentration of tea dust in the air provokes the development of respiratory diseases. As calculations show, the use of tea dust can bring certain incomes [1].

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2. Formulation of the problem

Tea leaves (Camellia sinensis plant) are distinguished by their unique chemical composition, including an unusually high content of biologically active substances, which, when brewed, dissolve in the aqueous extract. Tea is valued for its high palatability and physiological effect on the body [2,3].

Traditionally, tea is used as a drink, so the tea leaf chemicals are divided into two groups - water-soluble and ballast (insoluble in water). Water-soluble substances of tea are caffeine, flavonoids, tannin, sugars, pectin, B vitamins, ascorbic acid, organic acids, amino acids, water-soluble proteins and minerals [4]. Ballast substances include water-insoluble proteins (up to 20%), fiber, pectin, lignin and others. Caffeine and polyphenols have the greatest effect on the human body.

The tonic effect of caffeine is well known to tea consumers. The physiological effect of polyphenols is known mainly by nutritionists, cosmetologists and food production technologists. Tea polyphenols consist of flavonoids (catechins simple and complex, flavonols and their glycosides, anthocyanidins), tannins, phenol carboxylic acids (gallic, coffee, chlorogenic). Tea polyphenols have different types of biological activity: antioxidant, anti-inflammatory, antibacterial, hepatoprotective and others [3,5,6,7,8,9]. Green tea has the highest polyphenol content - up to 20-25%; in this regard, green tea extracts are used in functional foods, drinks and cosmetics. At tea enterprises located in Russia, the main non-recyclable waste (residue) is tea dust - fine powdery particles of dry tea leaves. It can be assumed that tea dust will correspond to tea products produced by the enterprise in terms of the content of biologically active substances. The rich chemical composition of tea gives great potential for the use of secondary tea resources for the production of biologically active compounds for various purposes - in animal feed, in cosmetic products, dietary supplements and others. The possibility of obtaining caffeine, microcrystalline cellulose, and bioethanol is currently being discussed from tea wastes [1,10,11].

The aim of the work is to analyze the chemical and biological potential of tea dust, which is currently a waste of tea packing enterprises, and to determine the possibility of rational use of tea dust.

3. Materials and methods

We studied an average tea dust sample, made up of 10 point samples taken at the production facilities of a tea packing enterprise. Samples of black leaf tea and green leaf tea produced by this enterprise were also analyzed. The appearance and organoleptic characteristics of dry samples and their aqueous extracts were evaluated for all samples. Preparation of extracts: 100 cm$^3$ of water with a temperature of 95-100 °C was added to 2 g of the sample, the extraction time was 5 min, then the extract was separated from solid particles.

Physicochemical parameters were determined in all samples: humidity, total content of water-soluble extractive substances, mass fraction of moisture, total ash content (GOST 32573-2013 Black tea. Specifications. Interstate standard).

The chemical composition of the samples was studied by the following indicators: water-soluble polyphenols, total and non-protein nitrogen, protein, reducing sugars, sucrose, fiber, and starch. The content of nitrogen, protein, carbohydrates was determined by known methods of laboratory biochemical analysis: nitrogen and protein - according to the Kjeldahl method, reducing sugars - according to the Bertrand method, sucrose - according to the number of reducing sugars formed after its hydrolysis, fiber - according to the Kürschner method, starch - according to the method Evers [12].

The content of water-soluble polyphenols was determined by the method developed by I. Shchegoleva and colleagues (Patent for the invention of the Russian Federation No. 2519767, IPC G01N 33/02, priority from 05.22.2013). The method involves the extraction of polyphenols from a ground tea sample, the determination of the concentration of polyphenols in the extract by the colorimetric method using Folin-Ciocalteu reagent. To obtain the extract, a ground tea sample was taken weighing 1.0 g and 50 cm$^3$ of water with a temperature of 95-100 °C, insisted for 5 minutes and filtered, the resulting extract was diluted with water 25 times. Then, 0.5 cm$^3$ of the diluted extract was taken, 3.0 cm$^3$ of a 0.5 M Na2CO3 solution and 0.3 cm$^3$ of Folin-Ciocalteu reagent were added to it, and after 2-3 minutes the optical density of the solution was measured at a wavelength of 765 nm. The
concentration of polyphenols in the diluted extract was determined by the calibration graph of the optical density of the tannin solution on the mass concentration of tannin in the solution. The amount of tea polyphenols transferred to the aqueous extract was expressed by their mass fraction in the analyzed tea sample.

Analyze were carried out in 3-4 replicates, the results were presented as arithmetic mean. To determine the confidence interval of the arithmetic mean result, Student's criterion was used at a significance level of $p = 0.05$. Mathematical processing of the results was carried out within the programs Statistica 6.0, Mathematics 5.2. and TableCurve 3D v4.0.01.

4. Discussion of results

Tea dust is a polydispersed powder, the organoleptic and physico-chemical characteristics of which depend on the tea raw materials processed by the enterprise - leaf black and green tea. Therefore, the analysis of the quality of tea dust was carried out in comparison with samples of black and green tea.

Table 1 shows the organoleptic characteristics of black, green tea and tea dust, as well as extracts obtained from them. According to the organoleptic characteristics of dry samples and extracts, we can conclude that the residues of black tea prevail in tea dust - the color of the tea dust sample is brick brown, the extract from it is red-brown, not transparent enough.

The taste and aroma of tea dust extract was closer to black tea. In general, the organoleptic characteristics of tea dust extract were worse than that of leaf black tea extract.

| Table 1. Organoleptic characteristics of tea samples and tea dust |
|---------------------------------------------------------------|
| **Name of indicator** | **tea dust** | **black leaf tea** | **green leaf tea** |
| Tea Appearance | Homogeneous powder | Homogeneous, evenly twisted | Homogeneous, evenly twisted |
| Tea color | Brown, uniform | Dark brown, uniform | Gray green, uniform |
| Tea extract color | Red brown, opaque | Bright, red brown, transparent | Yellow green |
| Taste and aroma of tea extract | Delicate aroma, tart taste | Delicate aroma, tart, slightly bitter taste | Delicate aroma, tart taste |

A comparison of the physicochemical parameters of tea samples and tea dust (Table 2) revealed some features for tea dust. The high dispersion of tea dust, the destruction of the structure of the biological tissue of tea leaves led to an increase in the extraction of water-soluble substances - compared with the black tea sample, extraction from tea dust increased by 3.17% and amounted to 35.64%. If we consider tea dust as an additional raw material for the production of biologically active substances, then with the correct selection of extraction modes, an increase in the yield of extractive in comparison with the obtained value can be expected. The content of water-soluble extractive substances in green tea at the level of 42.45% for the assessment of tea dust, in our opinion, is not significant due to the small proportion of particles of green tea in this tea dust sample.

| Table 2. Physico-chemical characteristics of samples of tea and tea dust |
|---------------------------------------------------------------|
| **Name of indicator** | **tea dust** | **black leaf tea** | **green leaf tea** |
| The content of water-soluble extractive substances | 35.64 | 32.47 | 42.45 |
| Moisture content | 7.45 | 6.85 | 7.05 |
| Total ash content | 6.19 | 5.97 | 5.80 |
Microparticles of tea dust have a large total surface, which increases the rate of moisture exchange with the surrounding air. These features affect the moisture content of the material. From the data of table 2 it is seen that the mass fraction of moisture in tea dust is higher than in samples of leaf tea. However, it can be assumed that at low humidity in the room, on the contrary, the processes of desorption of moisture from the material will prevail. In this case, the mass fraction of moisture in tea dust will be less than in leaf tea.

A change in the “total ash content” indicator indicates an increase in the mineral content of tea dust compared to leaf tea samples. Apparently, this is a steady trend, since tea dust may contain an admixture of mineral contaminants, especially when the sanitary conditions at the enterprise are not good enough. The studied tea dust sample has an ash content of 6.19%, which does not exceed the value allowed by the state standard - not more than 10% (GOST 32573-2013 Black tea. Technical conditions. Interstate standard).

The results of the study of the content of the main chemicals in tea dust and tea samples are given in table 3.

| Chemical content                  | The value of the indicator (%) for samples: |
|-----------------------------------|---------------------------------------------|
|                                   | tea dust          | black leaf tea | green leaf tea |
| Water-soluble polyphenols         | 7.46             | 7.95          | 16.22          |
| Carbohydrates:                    |                 |               |                |
| - reducing sugars                 | 2.73             | 2.61          | 3.7            |
| - sucrose                         | 1.88             | 2.20          | 2.15           |
| - cellulose                       | 5.05             | 5.62          | 6.90           |
| - starch                          | 0.12             | 0.10          | 0.12           |
| Nitrogenous substances:           |                 |               |                |
| - total nitrogen                  | 3.80             | 3.92          | 3.83           |
| - non-protein nitrogen            | 1.01             | 0.89          | 1.13           |
| - protein                         | 17.44            | 18.94         | 16.87          |

Polyphenols predominate in tea dust from water-soluble substances. The mass fraction of polyphenols passing into the aqueous extract when brewing a tea dust sample for 5 minutes amounted to 7.46% of the sample weight. This value is slightly lower than that of black tea and more than two times lower than that of green tea. The decrease in the content of polyphenols in black tea is caused, as is known [4], by oxidative fermentation of catechins in the primary processing of fresh leaves.

Reducing sugars and sucrose also pass into the aqueous extract. In tea dust, the total content of reducing sugars was 2.73%, sucrose - 1.88%. According to the content of these carbohydrates, tea dust and leaf tea samples were of the same type. Carbohydrates related to tea ballast substances are represented in tea dust in the following amounts: fiber - 5.05%, starch - 0.12%, which corresponds to their content in black tea.

The nitrogenous substances of tea are represented mainly by water-insoluble proteins and a small amount of free amino acids and water-soluble proteins. Our results show a high protein content in tea dust - 17.44%, but a significant portion of this protein does not get into the extract when brewing. Compared to the black tea sample, the protein content in tea dust is 1.5% lower. The ratio of total and
non-protein nitrogen in tea dust is 3.80%: 1.01%. Based on the data obtained, it can be concluded that with a certain technological processing, protein substances or their hydrolysates can be isolated from tea dust and find useful applications for them.

From table 3 it follows that the number of polyphenols that have converted to water extract from tea dust can be estimated as high. Based on this, tea dust can be considered as a promising raw material for the production of biological compounds with valuable functional properties. In the analysis, the conditions for the extraction of polyphenols were similar to the conditions for brewing tea with its traditional consumption. Earlier in studies [5], it was shown that the dissolution of phenolic and other substances of tea is affected by duration, temperature, and other extraction factors. We have studied the effects of extraction duration on water solubility of tea dust. For this, the content of water-soluble extractive substances and water-soluble polyphenols was determined at an extraction time of 5, 10, 20, 30, 40 minutes. The results are shown in table 4.

| Table 4. The effect of extraction time on the dissolution of extractive substances and polyphenols from tea dust |
|---------------------------------------------------------------|
| Name of indicator                                            | The value of the indicator, %, at the time of extraction, min: |
|                                                              | 5     | 10    | 20    | 30     | 40     |
| The content of water-soluble extractive substances           | 35.64 | 39.54 | 41.83 | 42.27  | 42.30  |
| Water-soluble polyphenols                                   | 7.46  | 9.18  | 10.04 | 10.31  | 10.32  |

It is shown that with an increase in extraction time to 20-30 min, the indicators increase: the content of water-soluble extractive substances - by 6.2-6.6%, the content of water-soluble polyphenols - by 2.58-2.85%. With continued extraction up to 40 min, the measured parameters remained almost unchanged. Thus, the possibility of obtaining biologically active substances from the waste of the tea processing industry was confirmed.

5. Conclusion

Tea dust was investigated - a waste of tea packaging enterprises. Organoleptic and physico-chemical indicators, the chemical composition of tea dust samples, leaf black and leaf green tea obtained from one enterprise were studied. It was established that black tea particles prevail in the composition of tea dust, which correlates with the share of this tea variety in the enterprise’s products. When brewing tea dust forms an extract with reduced organoleptic characteristics, but with a high yield of extractive substances - 35.64%. We did not detected increased contamination of tea dust with minerals; the total ash content in the tea dust sample was below the limit value established by GOST RF. Water soluble polyphenols, 7.46%, are present in tea dust in a significant amount, and a high protein content of 17.44% is noted in the insoluble residue. It is shown that the highest yield of water-soluble extractive substances, including water-soluble polyphenols, can be obtained in 30 minutes of extraction.

In general, analysis of tea dust showed the possibility of its use as an additional raw material source of biologically active substances.

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