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FERMENTATION TECHNOLOGY OF LEAVES FOR FLAVORED DRINKS

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Abstract: *The article shows options for fermenting tree leaves (cherries, apricots, lindens) and berries (raspberries, currants) to obtain aromatic raw materials. The purpose of the work is to obtain a modernized technology for obtaining dried leaves with the aroma of the corresponding fruits or berries. To obtain the desired effect, the possibility of using the tea leaf preparation technology was investigated. The basis of this technology consists of three main operations of preparing the leaf for drying - partial dehydration (or cold drying), leaf rolling, fermentation in a semi-closed vessel. Further, the fermented leaves are dried according to special regimes. It was found that the technology of tea leaf preparation can be successfully used for leaves of trees and berries. Three basic operations make it possible to obtain flavored leaves. The article shows that the intensity of the aroma and its correspondence to fruits and berries to a large extent depends on the conditions for the first operation - cold drying. The result of the study is that partial dehydration can be successfully carried out in two ways - classical (sheet packing in fabric layers) and modernized (freezing followed by defrosting). The upgraded method makes it possible to simplify the subsequent twisting operation and shorten the duration of fermentationDrinks from the leaves after fermentation are an alternative or a good addition to herbal teas.*

Keywords:*Fruit Tree Leaves, Berry Leaves, Fermentation, Tannins, Aroma*

INTRODUCTION

The chemical composition of the leaves of fruit trees and berries suggests the presence of aroma precursors identical to those contained in the fruits of these trees or berries. For example, there is reason to believe that the leaves of the apple tree may have similar components to the aroma of apple fruits. Norisoprenoid aroma precursors have been identified in saffron, gardenia fruit, and apple leaves (Knapp, H., Straubinger, M., Stingl, C., & Winterhalter P., 2002).We observe the similar situation with the aroma of leaves of other trees and berries (apricots, cherries, raspberries, currants), which under certain conditions can be formed during the processing of leaves. The purpose of this article is to determine the specific conditions and technologies under which the leaves of fruit trees and berries can reveal their potential in the formation of aromatic components. A prerequisite for substantiating such reactions is the technology of processing tea leaves, which can acquire different flavors depending on the conditions of enzymatic reactions. The production of black, white, red tea is based on the special conditions of oxidative processes and enzymatic reactions in tealeaves.

It is believed that the main biocatalyst of tealeaves during fermentation is polyphenol oxidase, through which all the main substances of the tanning complex are oxidized. Enzymes such as invertase, amylase, oxynitrolase, protease, pectinase and catalase are also of great importance. Therefore, the most important step in the manufacture of tea is the fermentation process. According to the degree of fermentation, tea is divided into fermented, semi-fermented, lightly fermented and unfermented.

The approbation of the technology for obtaining tea in the processing of leaves of fruit trees and berries is described in the article "Fermented leaves of fruit and berry crops as a raw material for drinks." The authors consider the results of the production of drinks close to tea from the leaves of fruit trees and berries (apple, cherry, mulberry, raspberry, etc.) (Hrynenko, I., Hrushetskyi, R., & Khomichak, L. 2019). However, the results of matching the aroma of leaves and fruits have not been studied.

The tea leaf processing technology is based on three main operations of preparing leaves for drying – partial dehydration (or cold drying), leaf twisting, and fermentation in a semi-closed vessel. Then, fermented leaves are dried according to special regimes. Various modes of fermentation or its absence give us white, green, yellow, red or black tea. Not every type of tea goes through the entire technological chain. For example, yellow and red tea are intermediate products between black and green. To obtain instant tea of high quality, the classical technology was modernized by crushing the leaves and squeezing the juice after harvesting. The juice is then fermented under certain conditions. The fermented juice is steamed, centrifuged and lyophilized to obtain an instant tea powder. The pressed leaf residue is subjected to fermentation and drying to prepare tea granules. The technology is more profitable as juice and residue are converted into value-added products in this method (Sinija, V. R., Mishra, H. N., & Bal, S., 2007).

EXPOSITION

Description Of The Technology For The Preparation Of Fermented Leaves

A special feature of the preparation of leaves from fruit trees and berries is the method of withering (cold drying). Withering is the preliminary stage of tea processing, in which the tea leaves undergo physical and chemical transformation for the next stages. When processing tea, the moisture content of tea leaves is of great importance. Withering is a partial drying process to remove the surface and core moisture of tea leaves. Cold drying removes some of the moisture by evaporation from the leaves before fermentation. A broad overview of the various scientific and technological aspects of withering and drying tea was presented (Sharma, A., & Dutta, P. P. 2018).

In our studies, the withering process was carried out in two ways:

1. The leaves were placed in the freezer for 36 hours or more (for example, the leaves can be used for processing 1-3 months after being placed in the freezer).

2. The leaves were laid out on fabrics and covered with a fabric from above (or twisted into a fabric with leaves into a tourniquet).

The use of two different ways of preparing leaves allows us to model a different approach to the further technology (Fig. 1):

- Accelerated fermentation technology, according to which frozen leaves were thawed at room temperature for about 2-2.5 hours. Extending the defrosting time can result in the loss of valuable aroma precursors. The leaves were then ground in a blender or similar devices. The resulting mass was placed in a container in a dense layer. Then it was covered with a damp semi-permeable gauze-type cloth to maintain humidity inside the container. The mass in the tank was fermented for 4-6 hours. During this period, the mass acquired a dark color and an aroma characteristic of the fruits of the trees or berries from which the leaves were collected was formed.

- Traditional fermentation technology, when at the end of the withering process, the leaves are twisted into a tube, so that the leaf is partially damaged. The twisted sheet was placed in a dense layer in a container. Then it was covered with a damp semi-permeable cloth such as gauze to maintain humidity inside the container. The mass in the tank was fermented for 10-14 hours. During this period, the mass acquired a dark color and an aroma characteristic of the fruits of the trees or berries from which the leaves were collected was formed.

For fermentation, it is necessary to keep a warm temperature in the room – 25-28 ° C. The cloth covering the leaves must be damp, i.e. if the room is dry, then it needs to be moistened periodically. The smell of the fruit mass will intensify during fermentation, and the color will darken. In some cases, to determine the completion of fermentation, you can focus on the strength of the smell. When the smell becomes very bright and and the color is dark, you can proceed to drying the tea. If the mass is kept on fermentation longer, the smell will change significantly or become subtle.

Fig. 1 Leaves fermented by traditional and accelerated technology

Drying technology for fermented leaves

Each stage of processing has played an important role in changing the aromatic profile of the leaves of fruit trees and berries. Drying fermented leaves, unlike drying tea leaves, should not improve the flavor, but should preserve it carefully. The slightest change in drying parameters can destroy the authentic aroma. Too harsh or long regimens cause the smell of dried grass or hay in the final product. The difference between drying tea leaves and tree leaves is that tea leaves contain high amounts of flavonoids, including catechins, theaflavins and flavonols, and when dried, their content can increase further.(Lee, M. K., Kim, H. W., Lee, S. H., Kim, Y. J., Asamenew, G., Kim, J. B., 2019).

We have found that it is necessary to dry the fermented leaves (according to the accelerated fermentation technology) in an oven at temperature of 65°C for 0,5-0,75 hours, and then at temperature of 40-45°C until completely dry, stirring occasionally with a spatula. Leaves fermented according to the traditional technology are best dried in the air at temperature of 26-30°C in the shade for 5 hours.

In recent years, new modernized approaches have been provided for the gentle drying of plant materials and tea leaves.For example, the work "Effect of different drying methods on the sensory quality and chemical components of black tea" shows that the organoleptic evaluation of black tea dried with a halogen lamp and the microwave was higher because the tea had a more uniform black color, a fresher taste and a more pronounced sweet aroma (Qu, F., Zhu, X., Ai, Z., Ai, Y., Qiu, F., &Ni, D., 2019). Microwave-dried black tea had the highest volatile compound content, followed by tea dried with a halogen lamp, then far-infrared dried. We also considered further ways to improve the gentle drying of fermented leaves.

Organoleptic Evaluation Of Drinks

The obtained samples of tea from the leaves of berries and fruit trees were brewed in the usual way (with hot water up to 90 °C, infused for 15 minutes in a sealed container) and then the intensity of the aroma and its identity with the fruits of trees or berries were compared (Fig. 2).

Fig. 2 Fermented leaf drinks

The evaluation was carried out in a descriptive manner, the results are shown in table.1. Using the gas chromatography method, we carried out studies of the similarity of the aroma of cherry leaves and cherry fruits. Dry leaves contained a large amount of esters (45 %), caryophylene oxide, kaurene (12%: kaurene -15-ene, kaurene -16-ene), aliphatic hydrocarbons (37 %), essential oil (6 %).Kaurenes belong to the class of gibberellins and can be found in growing young leaves. Caryophyllene $C_{15}H_{24}$ is a terpene hydrocarbon, exists in the form of two isomers, has a woody smell, and is used to make aromatic compositions. Benzaldehyde is found in fermented leaves as well as in fruits.

Table 1 Organoleptic evaluation of the aroma of drinks

№	Name of samples	Traditional fermentation	Accelerated fermentation technology
1	Cherry leaves	Intense cherry aroma with a hint of sourness	Cherry aroma with fruity undertones
2	Apricot leaves	Fruity aroma	Thesmell of dry leaves
3	Apple tree leaves	No characteristic apple flavor or fruity	Barely perceptible fruity aroma
4	Currant leaves	Characteristic currant flavor	Fruity aroma with a hint of currant
5	Raspberry leaves	Characteristic raspberry flavor	Fruity aroma with hints of raspberries

Drinks made from fermented cherry, currant and raspberry leaves demonstrated the best results. Drinks made from fermented apple leaves were recognized as the worst ones. According to the results of the organoleptic evaluation, the drink made from the leaves fermented by the accelerated technology was inferior in aroma intensity. In each sample, it was possible to understand the identity of leaves to fruits or berries (except for apple). The quality of the aroma of the leaves of the accelerated fermentation technology, in our opinion, depends on the degree of crushing the leaves after defrosting. A high degree of grinding leads to rapid (cascade) oxidation of the cell sap components by air oxygen. When prepared, leaves are damaged, cell sap oxidizes polyphenols with oxidative enzymes(Lou, W., Bezusov, A., Li, B., &Dubova, H., 2019). In the traditional technology, the destruction of the integrity of the leaf is much smaller and the oxidative processes proceed sequentially, with the maximum involvement of aroma precursors. For example, in the preparation of blue tea, the main purpose of the evaporation process is to preserve the catechins in a pure form, while in fermented black tea, the most complete oxidation of all catechins contained in the tea leaf occurs. (Davronovich, B. I., & Niyozovich, N.H., 2021).

The Role Of Enzymes In Flavor Formation

A review of the pathways for the formation of important carotenoid derivative aromatic compounds from the corresponding non-volatile aroma precursors is presented (Kong, J., Yang, X., Zuo, X., Su, X., Hu, B., & Liang, X., 2022). The authors show that high quality tea with desired properties and antioxidant activity can be obtained from fresh tea leaves using a two-step enzymatic approach. During a two-stage enzymatic treatment, 75 types of volatile compounds were identified in all treated samples. The authors found out that many volatile compounds of norisoprenoids were formed from reactive precursors, such as glycoconjugates and polyols. Therefore, in future research on the fermentation of fruit tree leaves, it will be more effective to carry out a two-stage fermentation by analogy with tea leaves. It is known that glycosidases play an important role in the enzymatic processes of the formation of plant aroma. A unique disaccharide-specific glycosidase from tea plants is used to release various aromatic compounds (Mizutani, M., et al., 2002). This specific enzyme is able to hydrolyze the glycosidic bond between disaccharide and aglycone and is deeply associated with the formation of floral aroma in oolong tea and black tea during flowering. The action of this enzyme is aimed at the hydrolysis of aromatic precursors – β-primeverosides (6-O-β-D-xylopyranosyl-β-D-glucopyranosides).

Until now, aromatic glycosides have been discovered and studied in many fruits, such as grapes, mangoes, lychees and others. The review by Liang Z. et al. provided information for future research on fruit-derived aromatic glycosides(Liang, Z., et al., 2022). The fruity aroma is mainly due to free and glycosidic-linked aromatic compounds. Aromatic glycosides structurally include an aromatic compound (aglycone) and a sugar moiety (glycone). They can be hydrolyzed to release free volatiles by endo- and/or exoglucosidase, while their biosynthesis refers to a glycosylation process with the use of glycosyltransferases. Aromatic glycosides can enhance taste perception through hydrolysis by β-glucosidase in human saliva.

In an experimental study acetone powder was prepared from freshly picked young leaves of the tea plant, which are known to exhibit high enzymatic activity. In study, acetone powder was prepared from freshly picked young leaves of the tea plant, which are known to have high enzymatic activity. The crude enzyme exhibited p-glucosidase activity and participated in the formation of (Z)-3-hexenol, inalool oxide I, linalool, methyl salicylate, geraniol, benzyl alcohol and 2-phenylethanol. When interacting with a crude enzymatic extract of tea leaves, geraniol was identified on gas chromatography as an enzymatic hydrolysis product(Yano, M., Okada, K., Kubota, K., & Kobayashi, A.,1990). Therefore, the fermentation process of foxes is the most important in the technology of their processing.

The benefits of drinks from the leaves of trees and berries

Both green and black tea leaves have strong anti-inflammatory effects related to their chemical composition (Chatterjee, P., Chandra, S., Dey, P., & Bhattacharya, S., 2012). Drinks using tree leaves and berries can have both a pleasant taste and beneficial properties. In the composition of cherry leaves, raspberry flavonoids are mainly represented by quercetin, which is one of the most powerful: it helps slow down the aging process, as it reduces oxidative reactions in the body, which are directly related to poor nutrition, increased stress, lack of sleep, etc. (Hrynenko, I., Hrushetskyi, R., & Khomichak, L. 2019). The main properties of quercetin include antiviral, antimicrobial, anti-inflammatory, antitumor and antiallergic ones. It plays an important role in the formation of the immune system. Currant and raspberry leaves contain vitamins, minerals, essential oils; they can be recommended as general strengthening components. Based on the data obtained, it can be concluded that the technology of fruit tree leaves fermentation can be recommended for industrial implementation.

CONCLUSION

The article shows options for the fermentation of tree leaves (cherries, apricots, lindens) and berries (raspberries, currants) to obtain fragrant raw materials. A modernized technology for obtaining dried leaves with the aroma of the corresponding fruits or berries was obtained. To obtain the desired effect, the possibility of using the tea leaf preparation technology was investigated. This

technology is based on three main operations of leaf preparation for drying - partial dehydration (or cold drying), leaf rolling, fermentation in a semi-closed vessel. Further, the fermented leaves are dried according to special regimes. It was found that the technology of tea leaf preparation can be successfully used for leaves of trees and berries. The article shows that the intensity of the aroma and its correspondence to fruits and berries to a large extent depends on the conditions for the first operation – cold drying. The result of the study is that partial dehydration can be successfully carried out in two ways - classical (sheet packing in fabric layers) and modernized (freezing followed by defrosting). The upgraded method makes it possible to simplify the subsequent twisting operation and shorten the duration of fermentation. Drinks from the leaves after fermentation are an alternative or a good addition to herbal teas.

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