Future Integrative Medicine **2024** vol. 000(000) | 000–000 Epub
DOI: 10.14218/FIM.2023.00077

Review Article

Overview of *Eurotium cristatum* and its Fermentation Application in Tea

Qian Zhang[1] and Ju Zhang[1,2*]

[1]*College of Biological Sciences and Engineering, Hebei University of Economics and Business, Shijiazhuang, China;* [2]*Institute of Cash Crops, Hebei Academy of Agriculture and Forestry Science, Shijiazhuang, China*

Received: September 07, 2023 | **Revised:** December 06, 2023 | **Accepted:** February 02, 2024 | **Published online:** March 19, 2024

Abstract

Eurotium cristatum (E. cristatum), commonly known as "golden flower", is the dominant strain in the microbial fermentation process of Fu brick tea. *E. cristatum* has favorable biological characteristics, including enzyme production, antimicrobial properties, immune regulation, antitumor properties, fat reduction capabilities, and weight loss benefits. With its probiotic characteristics, *E. cristatum* can be combined with different varieties of tea substrates to make a variety of fermented teas. More importantly, in the process of tea fermentation, *E. cristatum* can secrete a variety of extracellular enzymes, including some hydrolytic enzymes and oxidoreductases. They metabolize and transform various chemical components in tea through a series of reactions such as oxidation, degradation, and condensation, which significantly affect the quality of tea. In this review, by summarizing its basic functional characteristics as well as its application in fermented tea, an in-depth analysis of the key problems existing in the fermentation application of *E. cristatum* is described and some beneficial suggestions are presented in order to provide a rich theoretical basis for the development and utilization of *E. cristatum* to a greater extent.

Introduction

Under specific temperature and humidity conditions, *Eurotium cristatum (E. cristatum)* has the ability to form golden cleistocyst shells on the surface of Fu brick tea, earning it the nickname "golden flower".[1] *E. cristatum* is present during the flowering process of Fu brick tea and contributes to the fermentation process. The tea fermented by *E. cristatum* possesses various health benefits, including the ability to decrease blood glucose and blood lipid levels as well as to exhibit anti-oxidant properties.[2] *E. cristatum* has low nutritional requirements and can thrive in potato dextrose agar and rose bengal medium, showcasing its strong adaptability.[3] It is also crucial in enhancing the quality of tea. By obtaining nutrients from tea, *E. cristatum* undergoes a series of metabolic transformations. In addition, it produces a range of extracellular enzymes that catalyze and transform various substances in tea, which have a significant effect on the color, aroma, and taste of tea.[4] Researches have demonstrated that *E. cristatum* can significantly improve the biological activity of tea components.[5] Moreover, it can enhance the content of aromatic compounds in tea and reduce the content of bitter and astringent compounds, thus greatly improving the overall taste and quality of tea. The development and utilization of *E. cristatum* have revealed some promising effects. Studies have shown that *E. cristatum* possesses numerous functions, including weight loss, lipid reduction, anti-oxidation, inhibition of harmful bacteria, antitumor effects, and regulation of intestinal microflora.[6] In the future, these potential effects of *E. cristatum* are expected to drive the development of new fermentation products and offer vast application prospects. This review provides a comprehensive overview of the fundamental functional characteristics of *E. cristatum* and its applications in tea. It also describes directions for further research and development, aiming to facilitate the extensive and in-depth exploration and utilization of *E. cristatum*.

Keywords: *Eurotium cristatum*; Fermentation; Application; Tea.

Abbreviations: *A. chevalieri*, *Aspergillus chevalieri*; *A. cristatus*, *Aspergillus cristatus*; ABTS, 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid); *C. paliurus*, *Cyclocarya paliurus;* DNJ, 1-Deoxynojirimycin; DPPH, 2,2-diphenyl-1-picrylhydrazyl; *E. cristatum*, *Eurotium cristatum*; EC, epicatechin; ECG, epicatechin gallate; EGC, epigallocatechin; EGCG, epigallocatechin gallate; ITS, internal transcribed spacer.

***Correspondence to:** Ju Zhang, College of Biological Sciences and Engineering, Hebei University of Economics and Business, Shijiazhuang 050000, China and Institute of Cash Crops, Hebei Academy of Agriculture and Forestry Science, Shijiazhuang 050051, China. ORCID: https://orcid.org/0000-0002-0953-8451. Tel: +86-18033886880, E-mail: orangejuzhang@163.com

How to cite this article: Zhang Q, Zhang J. Overview of *Eurotium cristatum* and its Fermentation Application in Tea. *Future Integr Med* 2024;000(000):000–000. doi: 10.14218/FIM.2023.00077.

Overview of *E. cristatum*

Identification and nomenclature of E. cristatum

E. cristatum is one of the strains present during the flowering process of Fu brick tea that plays a vital role in determining the quality of tea. Therefore, numerous studies have been conducted to identify

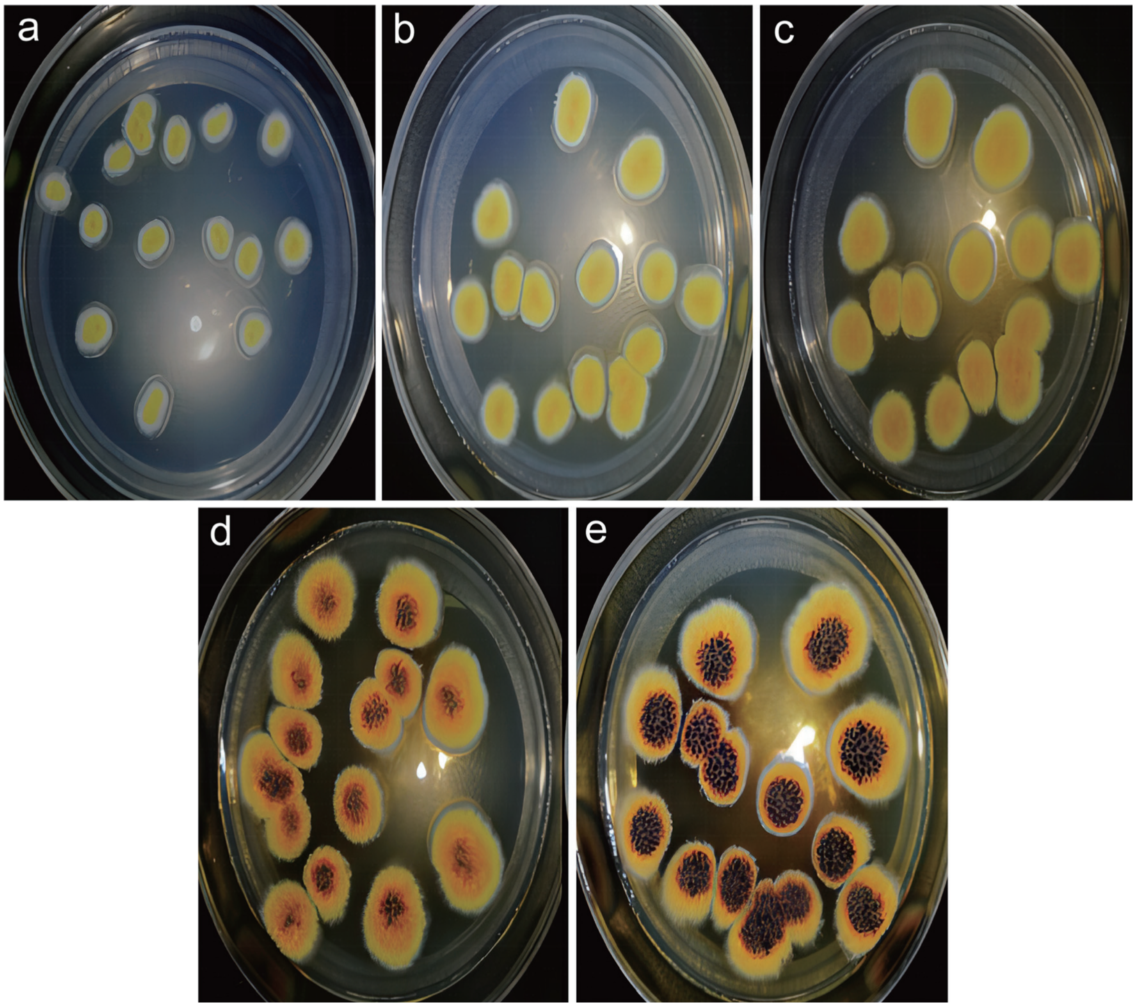

Fig. 1. Morphological characteristics of *E. cristatum* at different culture times. From (a)–(e), *E. cristatum* was cultured for 3 days, 4 days, 5 days, 6 days, and 7 days, respectively.

and name *E. cristatum*. Figure 1 shows the morphological characteristics of *E. cristatum* at different culture times. Initially, it was isolated from the "golden flower" found in dark teas such as Fu brick tea; hence, its common name is golden flower fungus. However, with the improvement of the isolation and identification technology of microorganisms, it was found that golden flower fungus contains many species and that it has a very rich microbial flora, including *E. cristatum*, *Aspergillus chevalieri (A. chevalieri)*, *Aspergillus cristatus (A. cristatus)*, etc. The process of identification and naming of *E. cristatum* has taken a long time. At first, in 1983, Professor Wen Qiongying named it *A. chevalieri*, but because one feature did not meet the requirements of the identification monograph, its name was changed to *A. cristatus*. Later, because it contains both sexual and asexual types, the name *A. cristatus* conflicted with Article 59 of the International Botanical Nomenclature, so it was finally named *E. cristatum*. Previous research reports have shown various identification results for the golden flower fungus,[7] which led to differences in its nomenclature. Table 1 shows the identification and naming of *E. cristatum* in tea from different sources.[8-13] In a study conducted by Yang *et al*.,[8] golden flower fungi were isolated from eight commercially available golden flower teas. Through isolation and identification, the fungi obtained from the golden flower included *Aspergillus coronatus* and *E. cristatum*. Additionally, *A. chevalieri* and *Aspergillus amstelodami* were also isolated and identified from these tea samples. It is worth noting that the microbial species present in these tea samples varied significantly due to the different tea types and processing techniques. However, microbial species within the same category exhibited greater similarity.

Basic functional characteristics of E. cristatum

E. cristatum possesses good biological efficacy, including enzyme production, bacteriostasis, immune regulation, antitumor effects, and lipid reduction. The production of extracellular enzymes has an important impact on the transformation of tea substrates, while the other characteristics have beneficial regulatory and improvement effects on the organism. Table 2 summarizes the important impact of *E. cristatum* fermentation on substrates and the organism.[14–25]

Enzymes produced by E. cristatum

In addition to meeting its own growth requirements, *E. cristatum* also plays a crucial role in the transformation, degradation, polymerization, and oxidation of various substances in tea. It possesses the ability to produce a range of extracellular enzymes, including

Table 1. Separation and identification of *E. cristatum* in different sources of tea

Tea classification	Tea variety	Fermentation degree	Identification method	Microorganisms in different tea samples	Reference
	Jingyang Fu brick tea	Fully fermented tea, the fermentation degree is 100%.	Morphology, and molecular identification	Aspergillus cristatus	8
	Niu Jinhua Fu brick tea	Fully fermented tea, the fermentation degree is 100%.	Morphology, and molecular identification	Aspergillus cristatus; Eurotium cristatum	8
	Jingwei Fu tea	Fully fermented tea, the fermentation degree is 100%.	Morphology, and molecular identification	Aspergillus cristatus	8
	Anhua dark tea	Fully fermented tea, the fermentation degree is 100%.	Morphology, and molecular identification	Aspergillus cristatus; Eurotium cristatum	8
	Anhua dark tea, yellow slices	Fully fermented tea, the fermentation degree is 100%.	Morphology, and molecular identification	Aspergillus cristatus	8
	Hunan Anhua, Golden Fu tea	Fully fermented tea, the fermentation degree is 100%.	Morphology, ITS	Aspergillus amstelodami	9
Dark tea	Guang xi black brick tea	Fully fermented tea, the fermentation degree is 100%.	Morphology, Multigene phylogenetic analysis (β-tubulin gene, calcium regulator protein gene and RNA polymerase II gene)	Aspergillus pseudoglaucus	10
	Hunan black brick tea	Fully fermented tea, the fermentation degree is 100%.	Morphology, Multigene phylogenetic analysis (β-tubulin gene, calcium regulator protein gene and RNA polymerase II gene)	Aspergillus cristatus	10
	Shaanxi Fu brick tea	Fully fermented tea, the fermentation degree is 100%.	Morphology, ITS, *β*-tubulin Phylogenetic analysis	Aspergillus cristatus	11
	Hunan Fu brick tea	Fully fermented tea, the fermentation degree is 100%.	Morphology, ITS, *β*-tubulin Phylogenetic analysis	Aspergillus cristatus	11
	Zhejiang Fu brick tea	Fully fermented tea, the fermentation degree is 100%.	Morphology, ITS, *β*-tubulin Phylogenetic analysis	Aspergillus chevalieri	11
	Sichuan Fu brick tea	Fully fermented tea, the fermentation degree is 100%.	Morphology, Molecular identification	Aspergillus cristatus; Aspergillus chevalieri; Aspergillus niger	12
	Guizhou Fu brick tea	Fully fermented tea, the fermentation degree is 100%.	Morphology, Phylogenetic analysis of multiple genes	Aspergillus cristatus	13
	Fuding golden flower old white tea	Lightly fermented tea, the fermentation degree is less than 10%.	Morphology, and molecular identification	Eurotium cristatum	8
	Pu'er raw tea	Lightly fermented tea, the fermentation degree is less than 10%.	Morphology, and molecular identification	Aspergillus cristatus; Eurotium cristatum	8
White tea	Tianfu tea	Lightly fermented tea, the fermentation degree is less than 10%.	Morphology, ITS	Aspergillus amstelodami	9
	Tianfu white tea	Lightly fermented tea, the fermentation degree is less than 10%.	Morphology, ITS	Aspergillus pali	9
	Tianfu Nan waxy shan cooked cake	Lightly fermented tea, the fermentation degree is less than 10%.	Morphology, ITS	Aspergillus niger	9
Black tea	Pu'er cooked tea	Fully fermented tea, the fermentation degree is less than 90%.	Morphology, and molecular identification	Eurotium cristatum	8
	Keemun Black Tea	Fully fermented tea, the fermentation degree is less than 90%.	Morphology, ITS	Aspergillus pali	9

ITS, internal transcribed spacer.

Table 2. Basic characteristics of *Eurotium cristatum* and the effects on substrates or the organism

Characteristics	Effects on substrate or organism	References
Enzyme production	Producing a variety of extracellular enzymes such as cellulase, protease, and polyphenol oxidase, polyphenol oxidase can reduce the bitter and astringent taste of tea, and improve the sensory quality of tea.	14,15
Antibacterial	The inhibitory effect on bacteria is significant, but it is insensitive to mold and yeast.	16–19
Regulate immunity, anti-tumor	The fungal polysaccharides and metabolic products produced by *Eurotium cristatum* itself have a good anti-inflammatory effect and can inhibit the growth of cancer cells.	20–22
Lose weight and reduce cholesterol	Significantly reduced the content of triglycerides, low-density lipoprotein, and total cholesterol in the body.	23–25

polyphenol oxidase, cellulase, and protease, which facilitate the conversion of macromolecular substances such as pectin, polysaccharides, and cellulose into smaller molecular compounds. This enzymatic activity contributes to improve the unique qualities and flavors in tea.[14] For instance, the polyphenol oxidase produced by *E. cristatum* can oxidize polyphenols in tea, resulting in the reduction of phenolic compounds, which leads to a reduction in the bitterness of the fermented tea. Li *et al*.[15] discovered that during the solid fermentation of green tea, the PE-1 strain of *E. cristatum* produced a variety of extracellular enzymes, including cellulase, xylanase, amylase, protease, and tannase. These findings highlight the superior enzyme production capacity of *E. cristatum* and its close association with the quality of tea.

Bacteriostatic effects of *E. cristatum*

During its growth and metabolic processes, *E. cristatum* produces metabolites that exhibit antagonistic effects on the growth and reproduction of other microorganisms, effectively inhibiting the proliferation of harmful microbes.[26] For example, Zhang *et al*.[27] conducted experiments extracting a total of six active components from the fermentation products of *E. cristatum*. Through analysis and detection, it was found that two of these active components, FS-IV and FS-VI, have significant bacteriostatic effects and display excellent stability at temperatures of −20°C to 100°C and pH 2–13. The remaining four components did not exhibit noticeable inhibitory effects. In addition, Li *et al*.[16] studied the fermentation broth of *E. cristatum* and discovered that inhibition on molds and yeasts was not prominent, while its inhibitory effect on bacteria was enhanced. The reason for this is that antimicrobial substances have different mechanisms of action on bacteria and fungi. For bacteria, antimicrobial substances mainly inhibit the growth and reproduction of bacteria by inhibiting the synthesis of their cell walls; while for fungi, antimicrobial substances mainly inhibit the function of the fungal cell membrane, that is, the permeability of the cell membrane is changed to inhibit the growth and reproduction of fungi. Therefore, the antimicrobial substances have different inhibitory effects on bacteria and fungi. A large number of studies have revealed that the fermentation broth of *E. cristatum* has a remarkable antimicrobial effect. Experimental results have indicated that certain substances produced during the growth of *E. cristatum* can hinder the growth and reproduction of other microorganisms. Moreover, Zhang *et al*.[17] employed various commonly used organic solvents to extract and identify active substances in the fermentation broth. Their results showed the presence of antimicrobial active components in the ethyl acetate extract, which exhibited significant inhibitory effects on actinomycetes and Gram-positive bacteria. Furthermore, it was observed that these antimicrobial active components display good stability under acidic and thermal conditions. Du *et al*.[18] isolated several aromatic glycosides from EN-220, which demonstrated inhibitory activity against *Escherichia coli*. Xiao *et al*.[19] investigated extracts from the propagules of *E. cristatum* and found that certain extracts exhibited potent inhibitory effects on actinomycetes, bacteria, and fungi. Notably, the strongest inhibitory effects were observed against *Escherichia coli* and *Staphylococcus aureus*. Additionally, these antimicrobial extracts display excellent thermal stability at 25–80°C and pH 2–6 as well as are unaffected by acidic conditions, demonstrating good overall stability.

Immune-modulating and antitumor effects of *E. cristatum*

Exopolysaccharides derived from *E. cristatum* have been shown to enhance the immune capacity and physiological function of the human body. Moreover, these polysaccharides exhibit strong antitumor activity and effectively inhibit the growth of cancer cells.[20] In addition to the immunomodulatory and antitumor activities of fungal polysaccharides, *E. cristatum* also produces other bioactive components with outstanding anti-inflammatory properties. Almeida *et al*.[21] have demonstrated that Compound 1, whose chemical name is 2-(2′,3-epoxy-1′,3′-heptadienyl)-6-hydroxy-5-(3-methyl-2-butenyl)benzaldehyde (Fig. 2),[21] is a secondary metabolite produced by *E. cristatum* that displays inhibitory effects on cell growth, making it a valuable candidate for anticancer and antitumor applications. Xu *et al*.[22] conducted a study on the anti-inflammatory effect and mechanism of benzaldehyde derivatives (2-6-H-5-B) derived from *E. cristatum* fermentation broth using lipopolysaccharide-induced RAW 264.7 cells. The results revealed that the 2-6-H-5-B compounds significantly inhibited the production of nitric oxide, tumor necrosis factor-alpha, interleukin 6, and monocyte chemoattractant protein 1 in activated macrophages, indicating strong anti-inflammatory activity. This experiment confirmed the potent anti-inflammatory activity of the benzaldehyde derivative 2-6-H-5-B derived from *E. cristatum* culture medium. In a study by Peng *et al*.,[28] *E. cristatum* fermentation broth was administered to immunosuppressed mice via gastric gavage for

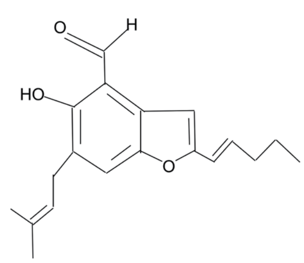

Fig. 2. The chemical structure of compound 1.[21]

15 days. The results demonstrated that the fermentation broth significantly enhanced the immune function of mouse cells. Further research revealed that the fermentation broth of *E. cristatum* could activate T lymphocytes and stimulate the production of the corresponding antibodies by B cells, thereby significantly improving immune function in mouse cells.

Weight loss and fat reduction effects of *E. cristatum*

In a study conducted by Kou *et al*.,[23] the effects of *E. cristatum* fermentation broth on lipid metabolism in hyperlipidemia rats were investigated using sweet potato tea as the substrate. Male rats were used as the experimental animals and were fed under specific temperature as well as humidity conditions. The results showed that fermented sweet potato tea significantly reduced the weight and Lee's index of obese rats as well as effectively decreased the degree of obesity. Furthermore, it promoted liver lipid metabolism in rats fed with a high-fat diet and reduced fat accumulation in their bodies. The levels of triglycerides, low-density lipoprotein, and total cholesterol in the serum of rats on a high-fat diet were significantly reduced. Additionally, Liu *et al*.[24] examined the lipid-lowering effect of *E. cristatum* in Jingyang tea. They studied the impact of black tea extract after being infused with *E. cristatum* on obese model mice. The experimental results demonstrated that fermented tea effectively inhibited body mass growth, decreased serum total cholesterol levels, and suppressed the increase in adipocyte volume while reducing the diameter of subcutaneous adipocytes. These findings provide valuable guidance and reference for the development of functional tea beverages aimed at lowering blood lipid levels. Moreover, Xiao *et al*.[25] investigated the effects of fermented orange peel black tea on the metabolism of mice induced by a high-fat diet. They found that the intervention of fermented orange peel black tea significantly improved the steatosis induced by a high-fat diet in mice. This improvement was mainly manifested by a reduction in vacuoles in mouse stem cells. The concentration of total cholesterol in mouse liver tissue was also significantly decreased.

Application of *E. cristatum* in fermented tea

E. cristatum is extensively utilized in diverse types of fermented tea, including mulberry leaf black tea, mulberry leaf green tea, litchi grass tea, *etc*. Table 3 shows the fermentation application of *E. cristatum* in different varieties of tea.[29–46] In addition, many researches have been conducted on the fermented tea extracts, which were derived from the fermentation of *E. cristatum*. During the fermentation process of *E. cristatum*, the bioactive components in different varieties of tea undergo some changes, leading to significant impacts on the taste, aroma, and color of the fermented tea. The sensory quality of tea has been demonstrated to be enhanced through fermentation with *E. cristatum*, as evidenced by the data presented in column 5 of Table 3. The relationship between this change and the content of the main chemical components was also analyzed.

Effect of E. cristatum on tea taste

The amino acid content and polyphenol content of tea are crucial indicators that reflect tea quality and are closely related to the formation of the tea taste. During the process of fermentation, *E. cristatum* utilizes tea amino acids as a nitrogen source for its growth and synthesizes its own substances. Consequently, as the fermentation degree of *E. cristatum* deepens, the content of amino acids is decreased, which has a significant impact on the sensory quality of tea.[47] During the growth and metabolism of *E. cristatum*, various extracellular enzymes such as polyphenol oxidase, cellulase, pectinase, and protease are produced. These enzymes play a role in transforming tea components.[5] For example, in a study conducted by Ma *et al*.,[29] mulberry leaf black tea was inoculated with *E. cristatum*. The results showed that fermentation by *E. cristatum* led to an increased production of flavonoids and polysaccharides in mulberry leaf black tea. However, the content of polyphenols in fermented tea decreased. Similarly, Yang *et al*.[30] fermented lychee grass tea with *E. cristatum*. They observed a significant improvement in the flavor quality of the fermented lychee grass tea. Further investigation revealed that *E. cristatum* produced active metabolites during fermentation, which effectively enhanced the sensory quality of the fermented tea. The researchers also concluded that certain extracellular enzymes were produced by *E. cristatum* in the fermentation process, which facilitated the transformation, oxidation, and degradation of various components in tea. Polyphenol oxidase, for example, oxidizes phenolic compounds into quinones, thereby reducing the polyphenol content and significantly decreasing the bitter taste of fermented tea. Moreover, Zou *et al*.[31] discovered that fermented tea exhibits a reduced content of tea polyphenols, which leads to a decrease in the bitterness of tea soup as well as significantly enhances the sensory quality of tea.

Effect of E. cristatum on tea aroma

Fermentation of tea leads to the production of various ketones, alcohols, and aldehydes, causing changes in the composition and content of aromatic compounds. In a study conducted by Luo *et al*.,[32] the volatile components of black tea raw materials and Jinhua loose tea were analyzed, and the research results showed that the fermentation of *E. cristatum* contributed to a significant increase in the content of nine volatile components. These components included (*E*)-linalool 3,7-oxide, (*E*)-furan linalyl oxide, acetophenone, (*E*)-2-nonenal, (*E*)-2-octenal, (*E,E*)-3,5-undecadien-2-one, tridecane, (*E,E*)-2,4-heptadienal, and methyl salicylate. These nine volatile components contributed to the unique fungal fragrance of Jinhua loose tea. Additionally, Zheng *et al*.[48] fermented green tea extract with *E. cristatum* and detected a total of 38 aromatic compounds in the fermented extract, with 10 of them having a high aroma. Furthermore, several new active components with volatile aromas were discovered in the fermentation extract. Zou *et al*.[49] fermented ginkgo biloba leaves with *E. cristatum* and observed a decrease in alcohols and an increase in aldehydes as well as ketones after fermentation. They suggested that the transformation of these aromatic components may be related to oxidation during the metabolic process of *E. cristatum*. Moreover, Chao *et al*.[33] carried out solid-state fermentation of *Cyclocarya paliurus (C. paliurus)* tea using *E. cristatum* and found that the content of polyphenols and total free amino acids decreased by 53.04% and 10.74%, respectively. Through sensory evaluation and analysis of the main active substances of fermented *C. paliurus* tea, they identified 67 differential metabolites, with 31 of them being terpene compounds with a molecular formula of $C_{15}H_{24}$. These terpene compounds are the main contributors to the fruity and floral aroma of *C. paliurus* tea. Xiao *et al*.[50] pointed out that *E. cristatum* enables the physiological metabolism of terpenic alcohol. In addition, a study conducted by Peng *et al*.[34] inoculated *E. cristatum* on a series of berry tea-dark tea composites, which were obtained by combining berry tea and dark tea in varying proportions, and then the fermentation experiments were carried out by *E. cristatum*. Through sensory evaluation, they found that the flowering process resulted in an obvious fungal aroma in the

Table 3. Effect of *Eurotium cristatum* fermentation on quality of different kinds of tea

Tea species	Fermentation conditions	Changes in the major compounds	Changes in the biological activity	Changes in sensory quality	Reference
Mulberry leaf black tea	solid state	The contents of flavonoids and polysaccharides increased; polyphenol content decreased.	Hydroxyl radical scavenging capacity increased; DPPH radical clearance rate decreased slightly.	The tea soup exhibits a vibrant color and exudes a rich aroma, while the reduction in polyphenol content contributes to the alleviation of bitterness and astringency in its taste.	29
Litchi grass tea	solid state	Theabrownine, thearubin and theaflavin increased 1.29 times, 1.73 times and 3.02 times respectively; tea polyphenols, amino acids and soluble sugars were reduced by 31. 9%, 36. 3% and 25. 2%, respectively.		The bitterness and astringency are significantly reduced as a result of the decrease in polyphenol levels. The increased presence of theabrownine, thearubin, and theaflavin imparts a vibrant orange-red color to the tea.	30
Raw dark tea	liquid state	Theabrownine, free amino acids and total flavonoids were increased by 5. 08%, 76.75% and 14.40%, respectively; a total of 12 kinds of aromatic esters and alcohols were added; tea extract, total protein and tea polyphenols were reduced by 21. 95%, 53. 80% and 36. 36%, respectively.		The aroma is enhanced, characterized by a distinctive fungal fragrance attributed to the increase of aromatic esters and alcohols.	31
Golden flower loose tea	solid state	Increased aromatic esters and aldehydes; the contents of free amino acids, flavonoids, soluble sugars, tea polyphenols, myricetin, catechins, kaempferol and quercetin decreased.		The reduction in polyphenol levels contributes to a decrease in tea bitterness and astringency, while the increase in aromatic esters and aldehydes content results in an elevation of aroma components.	32
Cyclocarya paliurus tea	solid state	Aromatic alcohols increased and flavonoids increased by 25.66%; the content of triterpenes, soluble sugars, free amino acids and polyphenols decreased by 27.91%, 13.46%, 10.74% and 53.04%, respectively.		The increase in the concentration of aromatic alcohols contributes to a robust tea aroma, characterized by distinct herbal and fungal floral notes. Simultaneously, the reduction in polyphenol levels significantly diminishes the bitter and astringent taste of tea.	33
Berry tea compound raw dark tea	solid state	The contents of gallic acid and GCG increased; alkaloids and total catechin decreased.		The mellowness of tea is enhanced and the bitterness is mitigated as a result of the reduction in tea polyphenol content.	34
Golden flower white tea	solid state	Theabrownine, gallic acid, total flavonoids, theanine, caffeine and tea extract increased by 77.31%, 10.92%, 20.46%, 8.63%, 7.70% and 2.89%, respectively; thearubin, theaflavin, soluble sugars, free amino acids, catechin and tea polyphenols decreased by 30.96%, 48.83%, 9.38%, 27.44%, 52.89% and 24.26%, respectively.		The interconversion of theabrownine, thearubin, and theaflavin imparts a vibrant color to fermented tea, while a significant reduction in tea polyphenol content effectively mitigates its bitter and astringent taste.	35
Mulberry leaves green tea	solid state	Tea extract and DNJ increased by 3 times; polyphenols, flavonoids and polysaccharide decreased by 7.1%, 12% and 76.1%, respectively.		The tea soup exhibits a vibrant orange color and exudes a rich aroma, accompanied by golden flower granules. The reduction in polyphenol content effectively mitigates the bitterness and astringency of the tea soup.	36

(continued)

Table 3. *(continued)*

Tea species	Fermentation conditions	Changes in the major compounds	Changes in the biological activity	Changes in sensory quality	Reference
Acanthopanax senticosus tea	solid state	Amino acids and tea polyphenols were reduced by 2.99% and 6.94%, respectively.	Antioxidant activity was enhanced.	The optimal ratio of polyphenols to amino acids contributes to the sweet and mellow taste of fermented tea, while a decrease in tea polyphenol content results in a reduction of its bitter and astringent flavors.	37
Autumn green tea	solid state	The contents of gallic acid and theabrownine were increased by 3.68mg/g and 30. 49mg/g respectively; and the aromatic alcohols were increased; the contents of purine alkaloids, theaflavin, thearubin, polyphenols, flavonoids were reduced; the water-soluble carbohydrate compounds were reduced by 42. 63 mg/g; EGCG, ECG, EC were reduced by 0. 37 mg/g, 4. 99 mg/g, 0.40 mg/g, respectively.		The interconversion of theabrownine, thearubin, and theaflavin gives fermented tea a bright color, the increase in aromatic alcohol content gives unique aroma of fermented tea; and the appropriate ratio of polyphenols to amino acids gives sweet taste and mellow taste of fermented tea.	38
Docynia indica tea	solid state	Phloretin content increased.	Enhanced antioxidant and antimicrobial activities.	Safety and health improvement.	39
Green tea	solid state	Increased gallic acid content; tea polyphenols, flavonoids, ester catechin EGCG, and ECG were decreased.	The ability to lower blood pressure is improved.	The taste is mellow and rich in flavor.	40
Instant dark tea	liquid state	The content of non-ester catechins, alkaloids, thearubin and theabrownine increased; the content of ester catechins and free amino acids decreased.	DPPH radical Scavenging capacity is improved.	The bitterness is reduced due to the decrease in tea polyphenol content, the increase in the content of thearubin and theabrownine gives the tea soup a bright orange-red color.	41
Fu brick tea	solid state	Increased aromatic alcohols; the total amino acid content decreased; EGCG and ECG were reduced by 79. 03% and 69. 88% , respectively.		The increase in the content of aromatic alcohols enhances the aroma of fermented tea, while the decrease in polyphenol content reduces the bitter taste and astringent taste of the tea soup.	42
Dandelion tea	solid state	The content of polyphenols was reduced.		The tea soup has a bright color, full golden grains and a mellow taste.	43
Tartary buckwheat tea	solid state	Sweet amino acids, water extract, theabrownine content increased; aroma compounds increased; the contents of bitter amino acids, flavonoids, and tea polyphenols were reduced.	Enhanced total Antioxidant capacity and increased DPPH and free radical Scavenging capacity of ABTS.	The increase in the content of sweet amino acids gives sweet taste of fermented tea, while the decrease in the content of bitter amino acids and tea polyphenols reduces the bitter taste and astringent taste of the tea, the increase in the content of aromatic alcohols and esters enhances the aroma of fermented tea.	44
Eucommia ulmoides Tea	solid state	The content of chlorogenic acid increased 0.478 mg/g.		Golden flowers have full granules and rich aroma.	45
Tieguanyin Tea	solid state	The content of thearubin, theabrownine, total flavonoids, glucose, triterpenoids, total sugar, catechin, EC, EGC and C increased; the content of free amino acids, theaflavin, fructose, maltose, sucrose and polyphenols decreased; ECG and EGCG decreased by 88. 1% and 92.2%, respectively.	DPPH, hydroxyl radical, ABTS radical scavenging capacity, Fe^{3+} reduction capacity, total reducing power increased, and antioxidant activity improved.	The increase in the content of theabrownine and thearubin gives fermented tea a bright orange-red color, while the decrease in tea polyphenols significantly reduces the bitter taste and astringent taste of the tea.	46

ABTS, 2,2’-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid); DNJ, 1-Deoxynojirimycin; DPPH, 2,2-diphenyl-1-picrylhydrazyl; EC, Epicatechin; ECG, Epicatechin gallate; EGC, Epigallocatechin; EGCG, Epigallocatechin gallate.

black tea samples as well as in the Golden flower berry tea complex black tea samples. Likewise, Tu *et al*.[51] fermented liquid green tea beverage using *E. cristatum* and analyzed the aromatic components of the fermented tea beverage. They discovered a significant increase in the content of more than ten alcohol compounds with aromatic components, which endowed the fermented tea beverage with a unique aroma.

Effect of E. cristatum on tea color

During the "blooming" process, *E. cristatum* produces various extracellular enzymes that promote the formation of theabrownine. Theabrownine has high biological activity, and its increased content gives fermented tea a brown and red color. It may also be the main flavor substance in fermented tea.[50,52] Bo *et al*.[35] investigated the dynamic changes of the main taste substances during the processing of Jinhua white tea and found that the sensory quality of Jinhua white tea changed significantly after the "blooming" process. The fermented tea exhibited excellent sensory attributes. The tea soup displayed a vibrant orange-yellow color, possessed a mellow flavor with decreased bitterness, and emitted a distinctive aroma. After the accumulation of Shoumei loose tea, the color changed to yellow-brown, and the golden flowers inside the tea brick began to grow vigorously on the eighth day of flowering, achieving a good flower effect. The soup color of Shoumei loose tea changed from yellow to orange-yellow, and as microorganisms propagated and polyphenols oxidized, the overall soup color gradually deepened to a bright orange-red. Furthermore, Zheng *et al*.[36] fermented mulberry leaf green tea with *E. cristatum*. Sensory evaluation revealed that after fermentation by *E. cristatum*, a large number of golden flower fungi attached to the surface of mulberry leaf green tea, accompanied by a unique fungal aroma. The fermented tea exhibited a bright yellow-brown color, and the surface color of the fermented tea was pure.

Conclusions and perspectives

In summary, *E. cristatum* exhibits multifaceted biological effects including enzymatic production, bacteriostatic activity, immunomodulation, antitumor properties, as well as weight and lipid reduction. As a fermentation starter, it facilitates the transformation and metabolism of the tea constituents through processes such as oxidation, degradation, and condensation, thereby enhancing the sensory attributes and biological functionality of tea. Consequently, it represents a significant probiotic agent with substantial developmental potential. However, the current application of *E. cristatum* in fermentation still faces certain limitations, which are described below.

First, the fermentation variations among strains of *E. cristatum* remain unclear. The diversity of the source and the variety of *E. cristatum* strains have led to unclear studies on the composition differences and characteristics of the self-fermentation broth, and the ingredient markers for its biological activity have not been resolved, thus limiting the standardized management and precise application of *E. cristatum*.

Second, the fermentation and transformation mechanism of *E. cristatum* as a starter culture remains elusive. Currently, there is a wide range of fermented teas made with *E. cristatum*, but the fermentation characteristics, component transformations, and metabolic mechanisms of different tea substrates have not been comprehensively compared. The substrate specificity as well as advantages and disadvantages of various fermentation substrates remain unclear, which limits the application range of *E. cristatum* fermentation and the market share of related products.

Third, the active mechanism of *E. cristatum* and its fermentation products remains unclear, while the exploitation and utilization of its active functions are inadequate. Studies have demonstrated the immunomodulatory, antitumor, anti-oxidative, and intestinal microbiota-modulating activities of *E. cristatum*; however, the underlying mechanisms remain elusive. Moreover, while most fermented tea products rely on its sensory-enhancing properties, there is still a significant market gap for health foods and bioproducts that harness its active effects.

In light of the aforementioned issues, the following recommendations are proposed for future fermentation applications of *E. cristatum*:

1. Screening out superior strains of *E. cristatum* with high productivity. Selecting teas of diverse origins and grades, conducting separation, identification, and fermentation culture processes, as well as employing metabolomics technology, a comprehensive and in-depth investigation could be conducted on the metabolites present in fermented broth from different sources. The aim is to elucidate key quality markers and to identify the advantageous characteristics of high flowering efficiency of *E. cristatum* for quality control;
2. Optimize the fermentation conditions according to the inherent advantageous characteristics of the fermentation substrate. When utilizing *E. cristatum* for the fermentation of various substrates, the advantageous chemical composition of the fermentation substrate itself first needs to be accurately grasped. In the process of optimizing the fermentation substrate of *E. cristatum* by making use of modern microbial fermentation technology, the content of the target chemical component is utilized as an evaluation criterion to enhance the fermentation efficiency of *E. cristatum* to a greater extent;
3. Conduct further molecular mechanism exploration on the biological efficacy of *E. cristatum* and its fermentation products in order to clarify the target of its activity and to develop related biomedical preparations combined with genetic engineering technology. At the same time, it can be combined with the probiotic properties of *E. cristatum* to expand its application in the fermentation of nontea food, agricultural products, and medicinal and edible plants as well as other substrates.

Under the background of great health in today's society, there has been an increasing focus on the relationship between the biological efficacy of *E. cristatum* fermentation products and human health. In the future, utilizing important techniques such as metabolomics technology, modern microbial fermentation technology, and genetic engineering technology to develop an increasing number of health-care fermented products derived from *E. cristatum* will become an innovative direction for future development.

Acknowledgments

None.

Funding

This research was funded by the Central Government Guides Local Science and Technology Development Fund Project of Hebei Province (No. 226Z2801G), a Postdoctoral research project of Hebei Province (No. B2022005014), Science and Technology Innovation Projects of the Hebei Academy of Agriculture and Forestry Sciences (No. C21R0803, C22R0802), and Research Fund of Hebei University of Economics and Business (No. 2021SGYB04).

Conflict of interest

The authors declare no conflict of interests relevant to this study.

Author contributions

QZ summarized and organized this paper by searching and reading a large number of papers. JZ summarized the "Conclusions and perspectives" and mainly revised and edited the paper.

References

[1] Qin JQ, Luo ML, Zhang X, Ling FQ. Research process on medical value of *Eurotium cristatum*. Sci Tech Food Ind 2018;39(24):336–339. doi:10.13386/j.issn1002-0306.2018.24.057.

[2] Chen RY, Fan ZY, Pan YL, Gao Y, He C, Huang YX, *et al*. *Eurotium cristatum* biotransformation plant phenolic compounds and affects their biological activities: a review. Food R&D 2022;43(8):193–201. doi:10.12161/j.issn.1005-6521.2022.08.026.

[3] Cai ZA, Liu SC, Liu ZH, Hu ZR, Jia HX, Hu BH, *et al*. Cellulase enzymatic property of *Eurotium cristatum* from brick tea. Tea Sci 2010;30(1):57–62. doi:10.13305/j.cnki.jts.2010.01.003.

[4] Zheng WJ, Wan XC, Bao GH. Brick dark tea: a review of the manufacture, chemical constituents and bioconversion of the major chemical components during fermentation. Phytochem Rev 2015;14:499–523. doi:10.1007/s11101-015-9402-8.

[5] Jiang LZ, Wang L, Yang T, Zheng HN, Zhao JL, Xiang DB, *et al*. Research progress on *Eurotium cristatum* and its fermentation application. Sci Tech Food Ind 2022;43(4):454–462. doi:10.13386/j.issn1002-0306.2021030124.

[6] Huang Y, Shi R, Su EZ. Progress in the research and application of the *Eurotium cristatum*. Bioprocess Eng 2017;15(1):49–56. doi:10.3969/j.issn.1672-3678.2017.01.008.

[7] Wu F, Deng YZ, Qin YY, Jiang YH, Zhang LJ, Luo YC, *et al*. Isolation and identification of golden flower fungus in white tea. Agric Res and Appl 2021;34(6):1–6.

[8] Yang RJ, Wang QM, Peng WS, Ji AB, Zhang WJ, Yan L. Isolation and identification of microorganisms from 8 commercially available "Jinhua" tea. Tropical Agric 2019;39(10):81–88. doi:10.12008/j.issn.1009-2196.2019.10.014.

[9] Guan PP, Munkhbayar E, Huang ZB, Li SG, Ji JH, Chen SH, *et al*. Isolation and identification of 23 fungal strains in tea leaves. Jiangsu Agric Sci 2020;48(16):285-286+288-290. doi:10.15889/j.issn.1002-1302.2020.16.053.

[10] Wang L, Tan GH, Pan QL, Peng XY, Zhang WM, Pang M, *et al*. Two species of aspergillus forming yellow cleistothecia popularly known as "golden flower" in dark brick tea of China. Mycosystema 2015;34(2):186–195. doi:10.13346/j.mycosystema.130275.

[11] Zhao RL, Xu W, Wu D, Jiang YH, Zhu Q. Microbial community diversity of Fu brick tea produced in different regions by Illumina MiSeq technology. J Ecology 2017;36(7):1865–1876. doi:10.13292/j.1000-4890.201707.012.

[12] Liang XL. Isolation and identification of main molds and screening of dominant bacteria in Sichuan Fuzhuan brick tea. Guangdong Tea Ind 1996;(4):13–15.

[13] Tan YM, Wang YP, Ge YY, Ren XX, Wang YC, Liu ZY. Isolation and molecular identification of *Aspergillus cristatus* in fermented "fuzhuan" brick tea from Guizhou Province. Mycosystema 2017;36(2):154–163. doi:10.13346/j.mycosystema.160125.

[14] Wu KW, Yang LN, Zhu LJ, Wang B, Liu H, He YT, *et al*. Advances on the application of *Eurotium cristatum* in Fermented Tea. Food R&D 2018;39(1):189–193. doi:10.3969/j.issn.1005-6521.2018.01.037.

[15] Li RX, Fang HF, Wang GH, Yang MH. Comparative analysis of the ability of *Aspergillus* and *Europium* in dark tea to produce extracellular hydrolases. Guangdong Agric Sci 2019;46(1):108–114. doi:10.16768/j.issn.1004-874x.2019.01.016.

[16] Li JL, Hu BH, Zhao YB, Liu SC, Jiang YJ, Liu ZH. Anti-microbial Activity of Fermentation Supernatants of *Eurotium cristatum*. Food Sci 2011;32(11):157–160.

[17] Zhang FF, Liu F, Yuan C, Gao L, Wang Y, Ling PX, *et al*. Research on antimicrobial effects and characteristics of fermentation products of *Eurotium cristatum*. F&D Products 2019;21(1):62–65. doi:10.3969/j.issn.1672-979X.2019.01.015.

[18] Du FY, Li XM, Song JY, Li CS, Wang BG. Anthraquinone derivatives and an orsellinic acid ester from the marine alga-derived endophytic fungus *Eurotium cristatum* EN-22. Helv Chim Acta 2014;97(7):973–978. doi:10.1002/hlca.201300358.

[19] Xiao HS, Li TT, Tang H, Chen Y, Wang WJ, Liu C, *et al*. Antiiostatic activity of propagule extracts of *Eurotium cristatum*. Food and Fermn Ind 2020;46(14):65–69. doi:10.13995/j.cnki.11-1802/ts.023391.

[20] Guo M, Zhang BS, Jin XH. Research Progress on Fermentation of microbial polysaccharide. Microbiol Bulletin 2008;35(7):1084–1090. doi:10.13344/j.microbiol.china.2008.07.007.

[21] Almeida AP, Dethoup T, Singburaudom N, Lima R, Vasconcelos MH, Pinto M, *et al*. The *in vitro* anticancer activity of the crude extract of the sponge-associated fungus *Eurotium cristatum* and its secondary metabolites. J Nat Pharm 2010;1(1):25–29. doi:10.4103/2229-5119.73583.

[22] Xu YM, Huang YM, Shi J, Zhou JL, Zhou HY, Pu H, *et al*. Study on anti-inflammatory effect and mechanism of 2-6-H-5-B compound from *Eurotium cristatum*. Mod Appl Sci in China 2022;39(2):161–167. doi:10.13748/j.cnki.issn1007-7693.2022.02.004.

[23] Kou J, Shi LN, Ma TY. Effect of sweet potato tea fermented by *Eurotium cristatum* on lipid metabolism and gut microbiota in hyperlipidemic rats. Food and Fermn Ind 2023;49(16):231–239. doi:10.13995/j.cnki.11-1802/ts.034117.

[24] Liu W, Zhang GC, Li Q, Tian Y, Meng J, Zhong YT, *et al*. Study on identification and lipid-lowering effect of *Eurotium cristatum* in Fu tea from Jingyang county. J Food Safety and Quality Testing 2019;10(23):7907–7914. doi:10.19812/j.cnki.jfsq11-5956/ts.2019.23.018.

[25] Xiao J, Hou C, Chen X, Ying J, Zhu X, Wang LM, *et al*. Dark tea with pericarpium citri reticulatae improves glucose metabolism and lipid metabolism disorders induced by high-fat diet in mice. Food Sci 2022;43(5):133–142. doi:10.7506/spkx1002-6630-20210316-218.

[26] Zhang HY. Research progress on application of bursa of coronoid in fermented tea. Heilongjiang Sci 2018;9(22):30–31.

[27] Zhang W, Wang MY, You JG, Ni L. Fermentation optimization of culture medium and isolation and identification of antimicrobial active substances from *Eurotiumcristatum*. China Food News 2022;22(2):345–356. doi:10.16429/j.1009-7848.2022.02.037.

[28] Peng Y. The effects of *Eurotium cristatum* fermentation broth on immunological indicators in immunosuppressed mice. Food and Mach 2021;37(8):169–173. doi:10.13652/j.issn.1003-5788.2021.08.029.

[29] Ma YR, Wang SM, Li XZ, Wang H, He FT, Liu GP. Comparative on the functional properties of mulberry black tea fermented by *Phellinus igniarius* and *Eurotium cristatum*. Chinese Edible Fungus 2022;41(3):55-58+64. doi:10.13629/j.cnki.53-1054.2022.03.011.

[30] Yang LN, Wu KW, Xu QY, Wang RY, Qu G, Wu HT, *et al*. Effects of *Eurotium cristatum* fermentation on main quality components and flavor of *Salvia plebeia* tea. Food and Fermn Ind 2019;45(13):121–125. doi:10.13995/j.cnki.11-1802/ts.019965.

[31] Zou MM, Dong QH, Huang Y, Su EZ. Submerged liquid fermentation of raw dark tea by *Eurotium cristatum*. Bioprocess Eng 2019;17(4):409–417. doi:10.3969/j.issn.1672-3678.2019.04.012.

[32] Luo M, Yu MY, Yu LJ, Huang JA, Wang KB, Liu ZH. Effect of fermentation by *Eurotium cristatum* LJSC.2001 on the fermentation quality of raw dark tea made from different varieties. Food sci 2023;44(14):106–115. doi:10.7506/spkx1002-6630-20221024-233.

[33] Chao J, Luo Q, Li JL, Yuan Y, Zhou MX, Yin FY, *et al*. Variation of characteristic flavor and volatile substances in *Cyclocarya paliurus* fermented with *Eurotium cristatum*. Food and Fermn Ind 2023;49(9):57-64+81. doi:10.13995/j.cnki.11-1802/ts.033030.

[34] Peng YQ, Liu Y, Yu LJ. Analysis of Anti-Bacterial and Quality Components Contents Varieties of *Ampelopsis grossedentata*-Dark Tea Compounds With *Eurotium cristatum* Fermentation. Hubei Forestry Sci and Tech 2022;51(3):25–31.

[35] Bo JH, Gong LJ, Ye XM, Lu ZD, Li J, Luo WM, *et al*. Dynamic changes of main quality components in jinhua white tea processing. Mod Food Tech 2022;38(1):306-314+20. doi:10.13982/j.mfst.1673-9078.2022.1.0471.

[36] Zheng SH, Huang D, Luo HB, Zhang LL, Gong DG, Du H, *et al*. Study on the quality of mulberry leaf tea fermented by *Eurotium cristatum*. Food Sci Tech 2021;46(3):44–48. doi:10.13684/j.cnki.spkj.2021.03.009.

[37] Yang LN, Wu KW, Lin S, Wu HT, Li DH, Du JY, *et al*. Orthogonal array optimization of the *acanthopanax senticosus* tea based on sensory evaluation. J Bohai University (Nat Sci Edit) 2019;40(1):11–18. doi:10.13831/j.cnki.issn.1673-0569.2019.01.002.

[38] Xiao Y, Li M, Liu Y, Xu S, Zhong K, Wu Y, *et al*. The effect of *Eurotium cristatum* (MF800948) fermentation on the quality of autumn green tea. Food Chem 2021;358:129848. doi:10.1016/j.foodchem.2021.129848, PMID:33933981.

[39] Xie J, Chen J, Mei XR, Zhu MJ, Li XL, Du J, *et al*. Biotransformation of Phlorizin by *Eurotium cristatum* to Increase the Antioxidant and Antibacterial Activity of Docynia indica Leaves. Curr Microbiol 2021;78(4):1590–1601. doi:10.1007/s00284-021-02366-3, PMID:33686505.

[40] Liu L, Shi J, Yuan Y, Yue T. Changes in the metabolite composition and enzyme activity of fermented tea during processing. Food Res Int 2022;158:111428. doi:10.1016/j.foodres.2022.111428, PMID:35840188.

[41] An T, Chen M, Zu Z, Chen Q, Lu H, Yue P, *et al*. Untargeted and targeted metabolomics reveal changes in the chemical constituents of instant dark tea during liquid-state fermentation by *Eurotium cristatum*. Food Res Int 2021;148:110623. doi:10.1016/j.foodres.2021.110623, PMID:34507767.

[42] Xiao Y, Zhong K, Bai JR, Wu YP, Gao H. Insight into effects of isolated *Eurotium cristatum* from Pingwu Fuzhuan brick tea on the fermentation process and quality characteristics of Fuzhuan brick tea. J Sci Food Agric 2020;100(9):3598–3607. doi:10.1002/jsfa.10353, PMID:32100298.

[43] Ding L, Li XY, Liu JX, Wang YC. Study on the technology of dandelion fermented tea. Food R&D 2020;41(15):75–79. doi:10.12161/j.issn.1005-6521.2020.15.014.

[44] Wang L. Development and quality analysis of solid-state fermented tartary buckwheat leaves tea fermented by *Eurotium cristatum* [Dissertation]. Chengdu: Chengdu University; 2023. doi:10.27917/d.cnki.gcxdy.2022.000217.

[45] Zhang LH, Li ZZ, Zhao GY, Zong W. Process optimization of fermentation of *Eucommia ulmoides* tea by *Eurotium cristatum*. Sci Tech Food Ind 2019;40(21):118–123. doi:10.13386/j.issn1002-0306.2019.21.019.

[46] Zou JM, Song ZR, Cai DL, Cai BY, Zhang JH, Zhang GG. Analysis on the main active components and antioxidant activity of Tieguanyin tea fermentation by *Eurotium cristatum*. Sci Tech Food Ind 2021;42(22):369–375. doi:10.13386/j.issn1002-0306.2021020174.

[47] Wen YJ, Peng SF, Feng J, Liu RG, Kou J. The main components and efficacy of Fu tea. Food Safety Guide 2022(11):190–192. doi:10.16043/j.cnki.cfs.2022.11.037.

[48] Zheng MX, Li HJ, Chen SN, Zhao Z, Liu XQ, Li XH, *et al*. Effect of fermentation with *Eurotium cristatum* on aroma components of tea infusions. Food Sci 2019;40(18):223–228. doi:10.7506/spkx1002-6630-20181022-230.

[49] Zou M, Guo X, Huang Y, Cao F, Su E, Wang J. Improvement of the quality of Ginkgo biloba leaves fermented by *Eurotium cristatum* as high value-added feed. Processes 2019;7(9):627. doi:10.3390/pr7090627.

[50] Xiao Y, Li M, Liu Y, Xu S, Zhong K, Wu Y, *et al*. The effect of *Eurotium cristatum* (MF800948) fermentation on the quality of autumn green tea. Food Chem 2021;358:129848. doi:10.1016/j.foodchem.2021.129848, PMID:33933981.

[51] Tu Z, Mei HL, Li H, Liu XQ, Emmanuel A, Zhang CL, *et al*. Effects of co-fermentation by *Eurotium cristatum* and *Lactobacillus plantarum* on the quality of green tea liquid beverage. Tea Sci 2018;38(5):496–507. doi:10.13305/j.cnki.jts.2018.05.007.

[52] Xiao Y, Zhong K, Bai JR, Wu YP, Zhang JQ, Gao H. The biochemical characteristics of a novel fermented loose tea by *Eurotium cristatum* (MF800948) and its hypolipidemic activity in a zebrafish model. LWT 2020;117:108629. doi:10.1016/j.lwt.2019.108629.