SHORT COMMUNICATION

Utilization of Gynostemma pentaphyllum and Houttuynia cordata medicinal plants to make Jiaosu: a healthy food

Li Yanza\(^{a,c}\), Li Peng\(^{b,1}\), Zhang Yan\(^{f}\), Jiang Kangkang\(^{d}\), Dong Meng\(^{a}\), Hu Zhiyuan\(^{a}\), Zhao Yunlin\(^{d}\), Yang Guiyan\(^{c}\) and Xu Zhenggang\(^{a,c,d}\)

\(^{a}\)School of Materials and Chemical Engineering, Hunan City University, Yiyang, Hunan, China; \(^{b}\)Department of Nursing, Yiyang Medical College, Yiyang, Hunan, China; \(^{c}\)College of Forestry, Northwest A & F University, Yangling, Shaanxi, China; \(^{d}\)Hunan Research Center of Engineering Technology for Utilization of Environmental and Resources Plant, Central South University of Forestry and Technology, Changsha, Hunan, China

ABSTRACT

Jiaosu is a healthy food that has received increasing attention in recent years, while it mainly uses fruits as raw materials. In order to explore the feasibility of using Chinese medicinal plants to make Jiaosu, the study took Houttuynia cordata and Gynostemma pentaphyllum as examples to make Jiaosu products, and measured the main components and antioxidant capacity. The results showed that the color of the Jiaosu was dark yellow and the pH was acidic. Jiaosu products were rich in total protein, total sugar, vitamin E, and total0 phenols, of which total protein content was the highest. At the same time, Jiaosu products had strong antioxidant capacity. Enriching the form of healthy food is of great significance for maintaining human health in the post-epidemic era and the ageing era.

Utilización de las plantas medicinales Gynostemma pentaphyllum y Houttuynia cordata para elaborar jiaosu: un alimento saludable

RESUMEN

El alimento saludable jiaosu, para cuya elaboración se utilizan principalmente frutas como materia prima, ha recibido una atención creciente en los últimos años. Con el fin de explorar la viabilidad del uso de plantas medicinales chinas para su producción, el estudio utilizó, a manera de ejemplo, Houttuynia cordata y Gynostemma pentaphyllum en la elaboración de productos jiaosu, midiendo sus componentes principales y su capacidad antioxidante. Los resultados permitieron constatar que el color del jiaosu es amarillo oscuro y su pH ácido. Asimismo, los productos jiaosu resultantes mostraron ser ricos en proteínas totales, azúcares totales, vitamina E y fenoles totales, siendo las proteínas totales las que registraron un contenido más alto. Además, los productos jiaosu exhibieron una fuerte capacidad antioxidante. El enriquecimiento de los alimentos saludables es de gran importancia para el mantenimiento de la salud humana en la era postepidemia y en la era del envejecimiento.

1. Introduction

With the development of the economy, healthy eating has attracted more and more people's attention. With the popularization of homology of medicine and food, human beings have invented many health foods. During 2006 to 2015, a total of 7 882 health foods were registered in China Food and Drug Administration (CFDA; Qing et al., 2017). Even as an importing country, about half of adults in the U.S. eaten health food making from medicinal plants (Bailey et al., 2011). In recent year, with the increase of population aging and sub-healthy, the market for health food becomes more promising. Extracting functional substances from plants and adding them to food is the main method of making health food (Chevallier et al., 2021). On the other hand, using plants to make tea is another way of using medicinal plants (Pang et al., 2021). However, the extraction process often requires a strict technical condition, and the extraction efficiency of plant tea is low. Jiaosu fermentation process is a popular process for plant food in recent years (Jiang et al., 2021). Jiaosu only rely on natural fermentation, so it can not only be the industrially produced but also suitable for home production. Although there are many Jiaosu products, we still know very little about the properties of it. Houttuynia cordata is a herb in the family Saururaceae and it widely distributes throughout southeastern Asia (Ni et al., 2007). Green leaves and young roots of H. cordata are popularly consumed as high-quality agricultural vegetables or used as folk tea alone or combing with other herbs (Tian et al., 2012). H. cordata contains a wide range of polyphenols, which have been considered to be responsible for the antioxidant activity. The plant is also increasingly popular for adjuvant therapy because it has been shown to possess a variety of pharmacological functions, such as antiviral, antibacterial, antileukemic, and antiallergic activities (Huang, Hung et al., 2021; Mishra et al., 2021; Tian et al., 2012). More importantly, studies have confirmed that H. cordata has the preventive and
therapeutic effects on new coronaviruses, such as SARS-CoV-2 (Bahadur Gurung et al., 2021).

Gynostemma pentaphyllum is also a traditional Chinese medicinal herb, who belongs to family of Cucurbitaceae (Huang, Ming et al., 2021). G. pentaphyllum has been used in foods and supplemental products for hundreds of years in China. In recent decades, pharmacological studies have reported many functions of G. pentaphyllum, including antimicrobial, anticancer, antiaging, antifatigue, antiulcer, hypolipidemic, and immune-modulatory activities which are attributed to its various chemical ingredients, including saponins, amino acids, polysaccharides, flavonoids, organic acids, trace elements, and other chemicals (Ji et al., 2018). Even the main components present in the G. pentaphyllum have been identified the results showed that the plant is rich in secondary metabolites with potential antioxidant and anti-inflammatory properties (Mastinu et al., 2021). There are also lots of G. pentaphyllum products have been launched, including G. pentaphyllum tea, tablet, instant powder, capsule, oral liquid, and pill. At the same time, G. pentaphyllum has been proven to have good preventive and therapeutic effects on many viral infections (Ezeifeke et al., 2012; Okoye, 2013), such as H5N1 (Sornpet et al., 2017).

Phytochemicals can be regarded as best source of alternative and cheaper counterparts to synthetic medicines, specifically, plants possessing antiinfluenza activities are potential candidates. Both H. cordata and G. pentaphyllum are important medicinal and edible plants and have good antiviral potential. Although tea for the above plants is widely used, the extraction efficiency of phytochemical components is often low. At present, the COVID-19 is raging around the world, seriously endangering the safety of human life. Therefore, it is important to explore new ways of using the above plants. In the study, we tried to use the H. cordata and G. pentaphyllum to prepare Jiaosu, and the basic properties were determined.

2. Materials and methods

2.1. Plant collection and Jiaosu preparation

Both H. cordata and G. pentaphyllum plants were collected from Mount Heng (27°2’ 27°26’, 112°33’ 112°47’), Hunan, China in the summer of 2017. Mount Heng is a famous scenic spot in China, ensuring that the collected plants are free from heavy metal pollution. We collected the aerial parts of the above plants, including leaves and stems and then transferred them to the laboratory (Figure 1). The

![Figure 1. H. cordata and G. pentaphyllum Jiaosu and the raw material plants. A: H. cordata Jiaosu; B: G. pentaphyllum Jiaosu; C: H. cordata plant; D: G. pentaphyllum plant.](image)

Figura 1. Jiaosu de H. cordata y G. pentaphyllum y plantas de la materia prima. A: H. cordata Jiaosu; B: G. pentaphyllum Jiaosu; C: planta de H. cordata; D: planta de G. pentaphyllum.
collected plants are rinsed with purified water, cut to 2 to 5 cm and then air-dried. The raw materials were put into a 50 L plastic barrel according to the weight ratio of brown sugar, plant and water of 1:3:10, and then stirred them for ten minutes. The fermentation temperature was controlled between 20°C to 30°C and fermentation process lasted six months. Then the H. cordata and G. pentaphyllum Jiaosu were prepared. The Jiaosu solution was filtered out for further determination.

2.2. Determination of pH and components

The two Jiaosu were further filtered with a circular fast qualitative filter paper of 11 cm and then stored in glass test tubes. The color and taste of the two Jiaosu were recorded. The pH values were measured using the Leici PHS-3 C PH meter (INESA Scientific Instrument Co., Ltd, Shanghai). Total protein, total phenol, total sugar, vitamin E and alcohol content were determined. The total protein quantification kit, total phenol kit and vitamin E assay kit were purchased from Nanjing Jiancheng Bioengineering Institute (http://www.njjcbio.com) and the total sugar kit was purchased Shanghai yuaneye Bio-Technology Co., Ltd (http://www.shyua nye.com/). The measurement methods of the above indicators referred to the instruction manual. The 5 mL Jiaosu was diluted 5 times and then 10 mL of 2% potassium dichromate solution, 5 mL of concentrated sulfuric acid were added. After shaking for 10 minutes, the absorbance was determined at the wavelength of 610 nm. According to the above method, a standard curve was prepared basing different concentrations of alcohol. According to the regression equation and the absorbance of the sample solution, the alcohol content was calculated.

2.3. Determination of antioxidant capacity

DPPH, ABTS, and FRAP were selected to reflect the antioxidant capacity of Jiaosu. The DPPH were determined according to Jiang Kangkang et. al. method (Jiang et al., 2021) and the experimental operation was exactly the same. The free radical scavenging activity of each concentration of the sample was calculated as IC50, which indicated the volume to scavenge 50% of free radicals. Total antioxidant capacity assay kit (ABTS method) and total antioxidant capacity assay kit (FRAP method) were purchased from Nanjing Jiancheng Bioengineering Institute (http://www.njjcbio.com) and all specific methods referred to the instructions.

2.4. Statistical analyses

Each experiment was performed in triplicate and the statistical analysis was performed using IBM SPSS Statistics 26.0. Data was expressed as mean ± standard deviation (SD) indicating sample variability. Independent samples t-test was employed to explore whether two Jiaosu were significantly different (p < 0.05).

3. Results and analysis

3.1. The color and taste characteristics

Using both plant stems and leaves as raw materials can reduce the workload of making Jiaosu. The color of H. cordata was much darker than that of G. pentaphyllum, close to black, while the color of G. pentaphyllum was dark yellow (Figure 1). Both Jiaosu had a obvious acid and alcohol taste. At the same time, herbal scent was also very noticeable (Table 1). The pH of both Jiaosu range from 5.65 ± 0.03 to 6.73 ± 0.04, higher than currently produced Jiaosu (Table 2).

3.2. The main components of Jiaosu

The difference for total protein content of the two Jiaosu, was significant (p < 0.05). The total sugar content of H. cordata and G. pentaphyllum Jiaosu was 567.89 ± 14.81 mg/ml, 567.89 ± 19.59 µg/ml, and there was no significant different (p > 0.05). The contents of total phenols and vitamin E in the two Jiaosu were low, and both the difference was not significant (p > 0.05). The alcohol content of H. cordata was 6.30 ± 0.10 µL/ml, which was significantly lower than that of G. pentaphyllum Jiaosu (p < 0.05, Figure 2).

3.3. The antioxidant capacity

ABTS, FRAP, and DPPH are commonly used to measure antioxidant capacity. The ABTS and DPPH method are fast, simple and FRAP method is widely used in food and health products. The ABTS value of H. cordata and G. pentaphyllum Jiaosu was 1.05 ± 0.02 mM, 1.11 ± 0.07 mM, and there was no significant different (p > 0.05). From the perspective of FRAP and DPPH, the difference between the two Jiaosu was significant, and the G. pentaphyllum Jiaosu was significantly higher than the H. cordata Jiaosu (p < 0.05, Figure 3).

4. Discussion and conclusion

Nature is the most important source of human food. Diversified food forms can not only popularize the utilization, but also may increase the extraction efficiency of the plant active ingredients. In recent years, Jiaosu have become an popular health food, but most Jiaosu products are mainly based on fruits, such as Malus domeri, longan, apple-pear, grape, blueberry (Table 2). Although Lycium ruthenicum Jiaosu was produced (Qingchao et al., 2019, 2020), few studies have explored the using of traditional Chinese medicine plants to make Jiaosu, especially herbal medicine plant. The SOD enzyme of L. ruthenicum Jiaosu is higher than most of fruit Jiaosu, suggested that traditional Chinese medicine plants may have unique advantages as raw materials (Table 2).

This study took H. cordata and G. pentaphyllum as examples to discuss the feasibility of using them to make Jiaosu. Although it is natural fermentation, the success rate of Jiaosu preparation is extremely high, and the Jiaosu products are rich in nutrients and strong in antioxidant capacity. Both use of beneficial microorganisms, such as probiotics, yeast, to ferment plants and natural

### Table 1. The color and taste characteristics of H. cordata and G. pentaphyllum Jiaosu.

| Jiaosu     | pH            | Representation                                           |
|------------|---------------|---------------------------------------------------------|
| H. cordata | 6.73 ± 0.04*  | Dark yellow to black, obvious acid smell, light wine flavor, drug scent |
| G. pentaphyllum | 5.65 ± 0.03 | Dark yellow, obvious acid smell, lighter wine flavor, drug scent |

### Table 1. Características de color y sabor de los jiaosu de H. cordata y G. pentaphyllum.

| Jiaosu     | pH            | Representación                                          |
|------------|---------------|--------------------------------------------------------|
| H. cordata | 6.73 ± 0.04*  | Amarillo oscuro a negro, olor a ácido obvio, sabor a vino claro, sabor a medicamento |
| G. pentaphyllum | 5.65 ± 0.03 | Amarillo claro, olor a ácido obvio, sabor a vino claro, sabor a medicamento |
Table 2. Composition and antioxidant capacity of some Jiaosu products made from plant fruits.

| Plant raw materials | Fermentation process | Composition | Antioxidant activity | References |
|---------------------|----------------------|-------------|----------------------|------------|
| Malus domeri (Bois) | Natural fermentation | pH: 3.14–3.37 Total phenols (20d): 7.61 mg/mL Alcohol (18d): 16.7% vol Total sugar (55d): < 0.06 mg/ml SOD enzyme (24d): 16.27 U/ml | DPPH (20d): 84.11% | Qiao et al. (2018, 2019) |
| Yeast | | | | |
| Yeast + Acetobacter aceti | | | | |
| Yeast + Acetobacter aceti + Bacilli spp. | | | | |
| Longan | | | | |
| Saccharomyces cerevisiae + Acetobacter balch + Lactobacillus plantarum | Natural fermentation in the dark | pH: 3.75 Reducing sugar (90d): 37.041 ± 6.217 mg/ml Total sugar (90d): 79.123 ± 4.272 mg/ml | DPPH (48d): 94.41% | Qingchao et al. (2019, 2020) |
| Lycium ruthenicum | | | | |
| Blueberry | Natural fermentation | pH (36d): 4.3 Total phenols (36d): 2.308 mg/ml | DPPH (48d): 94.11% | Zengliang et al. (2013) |
| Lactobacillus plantarum + Yeast | | Protease: 55.76 U/ml SOD enzyme: 81.27 U/ml | ABTS (36d): 82.22% | Xin et al. (2018) |
| Apple-Pear | Natural fermentation | pH: 4.14 ± 0.02 PPO (50d): 26.26 ± 0.28 U/ml | DPPH (30d): 90.91%±0.74% | Hao’An et al. (2020) |
| Sea-buckthorn | Natural fermentation | pH (24d): 3.5 Total phenols (30d): 2.852 mg/mL | DPPH (30d): 94.87% | Yan-Ping & Jin-An (2016) |
| Schisandra chinensis | Lactobacillus plantarum | pH (140d): 6.916 Total sugar (140d): 4.02 mg/mL Total flavonoids (140d): 6.44 mg/mL | ABTS (40d): 47.45% | Hai-Ran et al. (2020) |
| Pitaya | Natural fermentation | pH (487d): 3.40 Total acid (487d): 0.133 mol/l | DPPH: 89.10% | Feixiang et al. (2019) |
| Mango and Pawpaw Mulberry | Natural fermentation | pH (15d): 4.47 ± 0.03 Glucose (15d): 9.73 ± 0.27 mg/mL Fructose (15d): 29.41 ± 0.25 mg/mL Total phenols (15d): 466.87 ± 4.82 μg/mL Total flavonoids (15d): 331.86 ± 2.15 μg/mL Anthocyanins (15d): 35.53 ± 0.25 μg/mL | ABTS (35d): 90.78 ± 0.57% | Rui-Hong et al. (2019) |
| Cudrania tricuspidata | Natural fermentation | Protein (270d): 300 mg/l Total amino acids (270d): 2407.9 mg/l Human essential amino acids (270d): 766.7 mg/l | DPPH: 96.72% | Jia (2018) |
| Black chokeberry Yeast + Lactobacillus plantarum | | | | |
| Blackcurrant | Natural fermentation | Total phenols: 1.365 mg/l Total acid (225d): 2.65 g/100 mL SOD activity: 1998.30 U/mL The total anthocyanin: 6.63 mg/100 mL The total phenolic: 8.45 mg/mL | Total antioxidant capacity: 614.20 U/mL | Qiuyuan (2019) |

Fermentation are widely used in the production process of Jiaosu (Table 2). For M. domeri Jiaosu, the antioxidant capacity of products fermented by beneficial microorganisms is higher than that of natural fermented products (Qiao et al., 2018, 2019). We may explore to ferment the Chinese medicine plants with beneficial microorganisms for industrial production.

In the post-epidemic era and aging society, healthy food is especially important for human health. This research is limited to preliminary discussion and communication. In the future,
we should continue to conduct in-depth research on the types of traditional Chinese medicine plants, fermentation process, functional substances, and mechanism of health food.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the [Key projects of State Forestry and Grass administration] under Grant [201801]; [Experimental Demonstration Station (Base) Science and Technology Innovation and Achievement Transformation Project from Northwest Agriculture and Forestry University] under Grant [TGZX2021-41]; [Research Foundation of Education Bureau of Hunan Province] under Grant [21C0664].

Data availability statement

The datasets supporting the conclusion of this article are included within the article and its additional files, as well as can be requested from Xu Zhenggang (xuzhenggang@nwafu.edu.cn)

ORCID

Xu Zhenggang http://orcid.org/0000-0002-7401-5163

References

Bahadur Gurung, A., Ajmal Ali, M., Lee, J., Abul Farah, M., Mashay Al-Anazi, K., & Al-Hemaid, F. (2021). Identification of SARS-CoV-2 inhibitors from extracts of Houttuynia cordata Thunb. Saudi Journal of
