Effects of *Polygonatum odoratum* Polysaccharides on the Quality of White Chili Peppers in Jars

Xiuqiang WANG[1], Li ZHOU[2], Chenzhong JIN[1], Yihong HU[1], Jing QIU[2], Yunyun ZHOU[1], Yan WANG[1]*

1. Hunan Provincial Collaborative Innovation Center for Field Weeds Control, Hunan University of Humanities, Science and Technology, Loudi 417000, China; 2. Lianyuan Fengleyuan Agricultural Development Co., Ltd., Lianyuan 417114, China

Abstract [**Objectives**] This study was conducted to investigate the effects of *Polygonatum odoratum* polysaccharides on the quality of white chili peppers in jars. [**Methods**] White chili peppers were pickled by adding different concentrations of *P. odoratum* polysaccharides with traditional pickling technology, and its nitrite content, pH and sensory quality were analyzed and detected. [**Results**] The results showed that, compared with the control group without adding *P. odoratum* polysaccharides, the nitrite content in white chili peppers in jars decreased after adding *P. odoratum* polysaccharides. When the addition amount of *P. odoratum* polysaccharides was 0.002%, the inhibition rate of nitrite reached the maximum. Under the same fermentation time, *P. odoratum* polysaccharides could significantly reduce the pH value of pickles. When the addition amount of *P. odoratum* polysaccharide was 0.002% and the pickling time was 3 months, the sensory quality of white chili peppers in jars was the best. At this point, white chili peppers in jars had rich aroma and tasted soft and sour, and the sour and salinity were suitable. As the fermentation time continued to increase, the chili aroma of white chili peppers in jars gradually decreased, and the sour taste became more pronounced. [**Conclusions**] This study can provide reference for the safety and quality control of white chili peppers in jars.

Key words *Polygonatum odoratum* polysaccharides; White chili peppers in jars; Pickling process; quality

DOI:10.19759/j.cnki.2164 -4993.2023.04.009

China is very rich in vegetable resources, with a production of 721 million tons in 2019 and a per capita share of 515.9 kg, both ranking first in the world[1]. The output value of vegetables accounts for the highest proportion of the entire agricultural output value, while pepper (*Capsicum annuum* L.) is the vegetable with the largest planting area, largest consumption, and most processing methods in China. The processing method of pickled white peppers is the most common for chili peppers. First, green peppers are blanched at high temperature and then exposed to the scorching sun to obtain through dehydration and decoloration, white chili peppers, which are then added with salt for pickling, and white chili peppers in jars are finally obtained after adding them into jars. White chili peppers taste soft, sour and spicy, with excellent layering, and have become an important side dish and flavored food in southern China[2].

Pickling is the most commonly used processing method in China to change the taste and flavor of vegetables and improve their nutritional value. Due to simple process, easy preservation, unique flavor, and ability to enhance appetite, pickled vegetables are deeply loved by consumers. However, in the fermentation process, it is easy to cause the loss of nutritional value of pickled vegetables and a nitrite content exceeding the standard. Nitrite has certain toxicity. When the human body ingests too much nitrite, it enters the blood to convert low ferrohemoglobin into methemoglobin, losing the oxygen carrying function and causing tissue hypoxia. Secondly, nitrite is easy to generate strong carcinogen, nitrosamine, in human body. Therefore, strict control of nitrite content in pickles plays a very important role in ensuring food safety and human health.

Polygonatum odoratum is a traditional medicinal and edible plant in China, in which Hunan *P. odoratum* and Sichuan *P. odoratum* having larger cultivation areas. Its rhizomes are often used for health care, prevention and treatment of metabolic syndrome such as hyperlipidemia, hyperglycemia, obesity and cardiovascular disease. *P. odoratum* is rich in a variety of bioactive substances and a variety of mineral elements needed by the human body[3]. *P. odoratum* can achieve different functions through the diversity of its components, including regulating blood sugar concentration, improving myocardial ischemia and antioxidant activity, and enhancing the body's immune system. Our research team also found in the early stage that *P. odoratum* polysaccharides may inhibit the formation of obesity in high-fat diet rats by regulating the gut microbiota[4-5]. Recently, we have found that *P. odoratum* polysaccharides have good antioxidant activity, and are capable of significantly enhancing the activity of serum SOD, CAT, and GSH-Px in high-fat diet rats and reducing the content of MDA in the blood. Recently, it has been reported that the nitrite content of pickled vegetables can be controlled by adding redox substances, such as Vc and tea extracts[6-7]. Therefore, on the basis of previous studies, we speculated that adding *P. odoratum* polysaccharides can reduce the nitrite content in pickled vegetables. In order to verify our hypothesis, white chili peppers were used as raw materials to study the effects of different amount of *P. odoratum* polysaccharides added in the pickling process on the change of nitrite content in the product, so as to provide some reference for reducing the nitrite content in pickled white chili pepper products.

Received: April 28, 2023 Accepted: June 29, 2023

Supported by General Project of Natural Science Foundation of Hunan Province (2022JJ30312); Enterprise Science and Technology Innovation Team Construction Project of Loudi Science and Technology Innovation Program in 2022.

Xiuqiang WANG (2003 -), male, P. R. China, major: agronomy.

* Corresponding author. Yan WANG.

Materials and Methods

Materials and instruments

Main experimental materials: White chili pepper (Lianyuan Fengleyuan Agricultural Development Co., Ltd.); edible salt (Lianyuan Fengleyuan Agricultural Development Co., Ltd.); *P. odoratum* polysaccharides (extracted by the research team at the earlier stage).

Main instrument: L3S visible spectrophotometer (Shanghai Yidian Analysis Instrument Co., Ltd.); electronic balance (Lianyuan Fengleyuan Agricultural Development Co., Ltd.).

Experimental methods

Pickling of white chili peppers in jars Prepared white chili peppers were added into 1 L vegetable jars, each of which was filled with the same weight of white chili peppers and salt (2%). The mouth of each jar was sealed with water, and then, white chili peppers were fermented in an indoor incubator at a constant temperature of 25 ℃.

Pickling method of white chili peppers in jars added with *P. odoratum* polysaccharides On the basis of normal fermentation, a certain amount of *P. odoratum* polysaccharide powder was added to white chili pepper jars, so that the concentrations of *P. odoratum* polysaccharides in the jars were 0.001%, 0.002%, 0.004%, and 0.006%, respectively.

pH determination Referring to the method of Piao *et al.* [8], the pH of white chili peppers in jars was determined.

Determination of nitrite content At the fermentation time of 1, 2, 3, 4, 5, and 6 months respectively, samples were taken from white chili peppers in jars with and without adding *P. odoratum* polysaccharide. The content of nitrite was determined by the N-naphthylethylenediamine dihydrochloride method[9], with some modifications.

Analysis of sensory quality of white chili peppers in jars Ten teachers from the food major of Hunan University of Humanities, Science and Technology were selected for certain training. Based on the method of Liu *et al.* [10-11] with some modifications, the quality of white chili peppers in jars was evaluated from four aspects: taste, smell, color, and shape. The average score of each quality was obtained, and the specific scoring standards are shown in Table 1.

Table 1 Standards for sensory evaluation of white chili peppers in jars

Indexes	Evaluation standard	Score
Taste (30%)	Delicious and suitable taste, no bitterness or astringency	30
Smell (20%)	Suitable sour flavor, strong pepper aroma, and no odor	20
Color (20%)	Light bright yellow color, no impurities	20
Shape (30%)	Complete shape, no cortical separation or severe damage	30

Data processing SPSS 21.0 software was used for statistical significance analysis, and the experimental results were expressed in the form of mean ± standard deviation ($\bar{x} \pm s$). The comparison of the mean values between two groups of samples was conducted using independent-sample t test, with $P < 0.05$ being significant and $P < 0.01$ being extremely significant.

Results and Analysis

Changes in pH content during the fermentation of white peppers in jars

During the fermentation process of white chili peppers in jars, changes in the main dominant microbial community can lead to changes in the pH of white chili peppers in jars, which can be used for predicting whether it is mature and the changes in its quality. The changes in pH value of white chili peppers in jars without or with the addition of *P. odoratum* polysaccharides under different fermentation time are shown in Fig. 1. Compared with the 1st month of fermentation, in the 3rd month of fermentation, the pH of white chili peppers in jars without or with the addition of *P. odoratum* polysaccharides significantly decreased, and both were less than 4.5, indicating that the white chili peppers in jars were basically fermented and matured at this time. Compared with the 3rd month, the pH value of the white chili peppers in the 4th month further decreased, but the rate of decrease slowed down. Moreover, there was no significant difference in the pH value of most white chili peppers in jars at the 3rd, 4th, 5th, and 6th months. However, after adding *P. odoratum* polysaccharides, the pH value of white chili peppers in jars was the lowest after the 6th month of fermentation, indicating that *P. odoratum* polysaccharides might provide a good environment for the growth of dominant bacteria such as lactic acid bacteria, thereby lowering the pH value of white chili peppers in jars. In addition, compared with 0.01%, 0.04% and 0.06% of *P. odoratum* polysaccharides, the pH value of white chili peppers in jars added with 0.02% of *P. odoratum* polysaccharides was the lowest, indicating that the decrease in pH value of white chili peppers in jars was not significantly dose-dependent on *P. odoratum* polysaccharides.

Effects of *P. odoratum* polysaccharides on nitrite content of white chili peppers in jars

Fig. 2 shows the dynamic change of nitrite content in white chili peppers in jars with and without the addition of *P. odoratum* apolysaccharides in the pickling process. For fermented white chili peppers in jars without and with *P. odoratum* polysaccharides, the nitrite content in white chili peppers in jars was the highest after 1 month of fermentation. In specific, the nitrite content in white chili peppers in jars without adding *P. odoratum* polysaccharides was 18.12 mg/kg, while the nitrite contents in white chili peppers in jars with 0.01%, 0.02%, 0.04% and 0.06% of *P. odoratum* polysaccharides decreased to 15.12, 14.19, 15.3 and 15.00 mg/kg, respectively, and the nitrite content of white chili peppers in jars added with 0.02% of *P. odoratum* polysaccharides was the lowest, which might be due to the fact that excessive *P. odoratum* polysaccharides were conducive to the growth of nitrate-reducing bacteria, causing the increase of nitrite in white chili peppers in jars. With the increase of fermentation time, the nitrite content in

white chili peppers in jars generally decreased and then stabilized (<4 mg/kg), which might be due to the decrease of dissolved oxygen in jars with the increase of fermentation time, which inhibited the growth of aerobic nitrate-reducing bacteria. Secondly, when the pH in jars was less than or equal to 4.5, the activity of nitrate reductase was reduced, thus inhibiting the formation of nitrite[12].

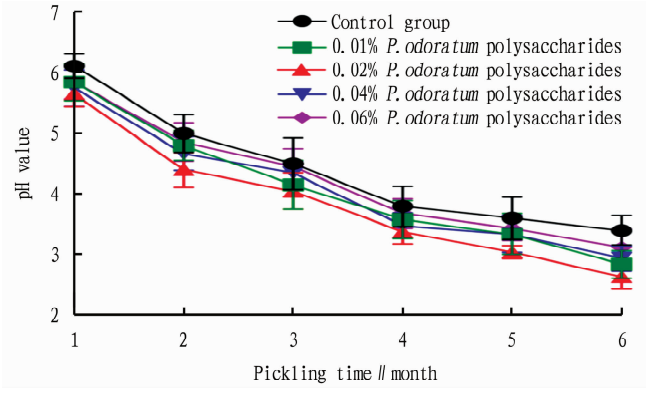

Fig. 1 Effects of *P. odoratum* polysaccharides on the pH value of white chili peppers in jars under different fermentation time

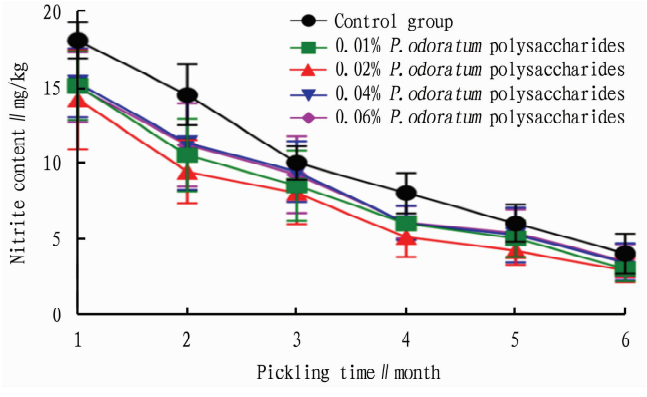

Fig. 2 Effect of *P. odoratum* polysaccharides on nitrite content of white chili peppers in jars under different fermentation time

Effects of *P. odoratum* polysaccharides on quality of white chili peppers in jars

The sensory quality scores of white chili peppers in jars without or with the addition of *P. odoratum* polysaccharides during the pickling process are shown in Fig. 3. For white chili peppers in jars without the addition of *P. odoratum* polysaccharides, as the fermentation time increased, the chili aroma of white chili peppers in jars became more and more intense, and the unique sour and spicy taste of white chili peppers in jars became more obvious. The coordination between sour and salty taste increased, and the sensory score of white chili peppers in jars first increased, reaching a maximum of 78 points in the 3rd month of pickling and fermentation. At this time, white chili peppers in jars had a rich aroma, and a delicious taste with moderate coordinated sour and salinity. Meanwhile, the shape of white chili peppers in jars was intact, without any cortical separation or severe damage, and no obvious vegetable chips were found. As the fermentation time continued to increase, a layer of white film appeared on the surface of white chili peppers, and white chili peppers gradually became soft in tissue, and exhibited damaged morphology, stronger source taste, and reduced palatability, so the sensory score significantly decreased. Compared with the control group, after adding different concentrations of *P. odoratum* polysaccharides to white chili peppers in jars, the sensory quality of white chili peppers in jars with different concentrations of *P. odoratum* polysaccharides was significantly improved at the same fermentation time. Under different concentrations of white chili peppers in jars, the optimal fermentation time for white chili peppers in jars was about 3 months. When the addition amount of *P. odoratum* polysaccharide was 0.002%, the sensory score of white chili peppers in jars was the highest, at 89 points. Meanwhile, the white chili peppers in jars had a strong aroma and no odor, and showed a unique pepper aroma. The taste was delicious, and coordinated in sour and salinity. From the 4th month of fermentation to the end of fermentation, the color, aroma, and taste of white chili peppers in jars decreased to a certain extent, and the texture gradually became soft. However, throughout the entire fermentation process, the shape of white chili peppers in jars was intact. In summary, it indicated that the addition amount of *P. odoratum* polysaccharides was optimal at 0.002%, and there was no dose dependence on the quality of white chili peppers in jars.

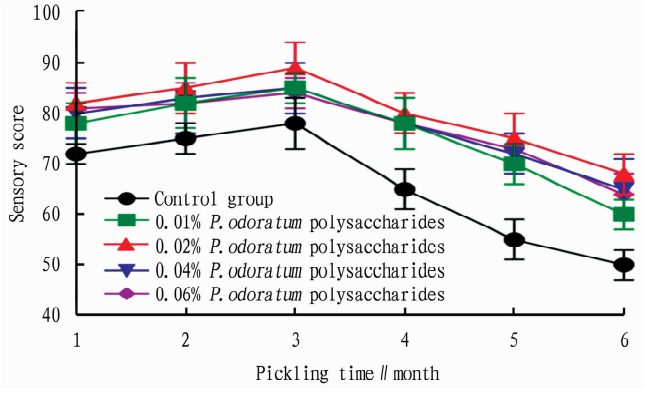

Fig. 3 Effect of *P. odoratum* polysaccharides on nitrite content of white chili peppers in jars under different fermentation time

Conclusion and Discussion

At the initial stage of pickling and fermentation of vegetables, due to the presence of a certain amount of mixed bacteria on their surfaces and pickling utensils, and the fact that lactic acid bacteria have not yet formed a dominant strain, lactic acid fermentation is slow, and pH is high, and the growth of mixed bacteria is relatively rapid, reducing nitrate to nitrite. Therefore, nitrite is inevitably formed in the process of pickling vegetables[13]. As an important indicator affecting food safety, reducing the content of nitrite is very important.

In recent years, there have been many reports on the scavenging effect of plant extracts on nitrite. For example, flavonoids in the leaves of *Styphnolobium japonicum* can remove the content of nitrite in pickled cowpea[14], and garlic extract can also remove the content of nitrite in salted fish[15]. In this study, it was found

that adding *P. odoratum* polysaccharides could significantly reduce the nitrite content in white chili peppers in jars, and when the amount of *P. odoratum* polysaccharide was 0.002%, the nitrite content in white chili peppers in jars was the lowest. It showed that 0.002% was the best way to reduce nitrite content, which is consistent with the reported results of *Astragalus membranaceus* polysaccharides in scavenging nitrite ions[16]. In addition, our study found that polysaccharides from *P. odoratum* also reduced the pH value of white chili peppers in jars to a certain extent. Moreover, at higher concentrations, the pH value of white chili peppers in jars decreased faster, indicating that higher concentrations of *P. odoratum* polysaccharides had a stronger effect in promoting fermentation and acid production by lactic acid bacteria. Therefore, without affecting the taste of white chili peppers in jars, the concentration of *P. odoratum* polysaccharides can be appropriately increased. The study on the sensory quality of white chili peppers in jars found that the overall sensory quality of white chili peppers in jars was the best when the amount of *P. odoratum* polysaccharides added was 0.002% and the fermentation time was 3 months. At this point, the white chili peppers in jars had the unique spicy and rich aroma of white chili peppers, no peculiar smell, harmonious sour and salinity, and a refreshing and suitable taste.

In summary, *P. odoratum* polysaccharides improved the quality and safety of pickles to a certain extent. When the addition amount of *P. odoratum* polysaccharide was 0.002%, the physicochemical and sensory indexes of white chili peppers in jars were better than those with other concentrations. Therefore, in actual production and life, a certain concentration of *P. odoratum* polysaccharides can be added to white chili peppers in jars to improve its sensory quality and inhibit the production of harmful substances such as nitrite.

References

[1] WANG ZD, SHI XY, ZHANG H. Current situation, problems and recommendations for vegetable seed industry in China[J]. Zhongguo Guacai, 2021, 34(9): 120-123. (in Chinese).

[2] SONG XB, PAN SL. Effect of blanching time on drying characteristics and quality of white chili[J]. Food Science, 2022(7): 177-185. (in Chinese).

[3] LI J, HSIUNG SY, KAO MR, *et al.* Structural compositions and biological activities of cell wall polysaccharides in the rhizome, stem, and leaf of *Polygonatum odoratum* (Mill.) Druce[J]. Carbohydr Res, 2022(521): 108662.

[4] WANG Y, LIN YX, KANG JH, *et al.* Effect of *Polygonatum odoratum* polysaccharides on lipid metabolism in high-fat diet fed mice[J]. Acta Nutrimenta Sinica, 2018, 40(4): 353-359. (in Chinese).

[5] WANG Y, FEI Y, LIU L, *et al.* *Polygonatum odoratum* polysaccharides modulate gut microbiota and mitigate experimentally Induced obesity in rats[J]. International Journal of molecular sciences, 2018, 19(11): 3587.

[6] SUN ZD, MAO PC, CHEN JS, *et al.* Effects of vitamin C and spices on nitrite concentration during cabbage saline process[J]. Food and Fermentation Industries, 2017, 43(8): 185-189. (in Chinese).

[7] SUN ZD, HU XX, LIANG YR, *et al.* Study on pickling technics and dynamic of nitrite in the pickled cabbage[J]. Food Science and Technology, 2007, 32(9): 78-81. (in Chinese).

[8] PU YG, ZHANG JB, CUI CZ, *et al.* Determination and correlation analysis of tobacco non-volatile organic acids and pH[J]. Food and Machinery, 2022, 38(2): 32-39. (in Chinese).

[9] LI Y. Effects of storage conditions on nitrate, nitrite and quality of spinach[D]. Lanzhou: Lanzhou University of Technology, 2014. (in Chinese).

[10] LIU H. Dynamic study on the quality changes during natural fermentation and the fermentation process of artificial inoculated pickles[D]. Chengdu: Xihua University, 2012. (in Chinese).

[11] SONG XB, PAN SL, WU S, *et al.* Heat pump drying characteristics and process optimization of white peppers[J]. Food and Fermentation Industries, 2022: 1-14. (in Chinese).

[12] CHI XM, ZHANG QF, CHI NY, *et al.* Research progress of the safety of fermented vegetables[J]. China Brewing, 2018, 37(8): 5-8. (in Chinese).

[13] YANG Y, WANG WS, WU YJ, *et al.* Research progress on control technology of nitrite in pickles[J]. China Condiment, 2020, 45(10): 197-200. (in Chinese).

[14] LENG X, YANG Y, CHEN F, *et al.* Study on the extraction of flavonoids from the leaves of *Styphnolobium japonicum* and its nitrite scavenging effect on pickled cowpea[J]. Guangxi Journal of Light Industry, 2021, 37(12): 10-35. (in Chinese).

[15] CAO CH, HE YQ, LIANG QQ, *et al.* Study on clearance effect of garlic extract on nitrite in salted fish[J]. China Condiment, 2020, 45(11): 1-4. (in Chinese).

[16] LI ZY, CHENG LL. The effect of astragalus polysaccharides extracted from β-cyclodextrin derivatives on the removing of nitrite[J]. Food and Fermentation Industries, 2011, 2(37): 70-72. (in Chinese).

Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU

(Continued from page 21)

[14] JAESCHKE H, KLEINWAECHTER C, WENDEL A. NADH-dependent reductive stress and ferritin-bound iron in allyl alcohol-induced lipid peroxidation in vivo: The protective effect of vitamin E[J]. Chemico-Biological Interactions, 1992, 81(1-2): 57-68.

[15] ZHANG Z, BLAKE DR, STEVENS CR, *et al.* A reappraisal of xanthine dehydrogenase and oxidase in hypoxic reperfusion injury: the role of NADH as an electron donor[J]. Free radical research, 1998, 28(2): 151-164.

[16] YAN YL. The protective effect of anthocyanin on oxidative stress and NF-κB pathway in mice with acute kidney injury[D]. Hefei: Anhui Medical University, 2021. (in Chinese).

[17] HU RH, RAO MD. The pathogenesis of alcoholic liver disease[J]. Clinical Journal of Hepatobiliary, 1986, 2(2): 72-76. (in Chinese).

Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU