New Process for Extracting Oil and Starch from Tea Seeds

Jinzhong Jiang, Cuijuan Ren, Zibu Wang, Changjiang Qian, Yuxiao Shen and Ya Yang

Guizhou Bioresource Development and Utilization Key Laboratory, Guizhou Normal College, Guiyang 550018, China

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Abstract: A new process for extracting oil and starch from tea seed was introduced. The new process included one special link compared with all of the processes used now for tea seed oil and starch production. The link was static fermentation by which oil bodies and starch were separated naturally from tea seeds. By the process, tea seed oil and starch which were in conformity with government standards about edible oil and starch were successfully produced with 16% and 8% of production rate, respectively. The new process has many advantages, such as more simple equipments, lower production cost and whole natural products, etc..

Key words: *Camellia sinensis*, tea seed, fermentation, tea seed oil, tea seed starch.

1. Introduction

Tea seed oil (TS oil) and tea seed starch (TS starch) are edible and made from tea seed (*Camellia sinensis*). Tea seed contains 18%-30% oil, abundant starch and protein, and has great value to develop [1]. TS oil is rich in unsaturated fatty acids, vitamin E and tea polyphenol. The research of modern medicine indicates that it can prevent and cure cardiovascular and cerebrovascular diseases, reduce blood press, protect against radiation exposure and oxidization, maintain beauty and keep young, delay senescence and relax bowel. Therefore, TS oil is honored as East olive oil and selected specially as edible oil for astronauts in China. Also TS oil was approved as new source of food by Chinese Ministry of Health in 2009.

The meanings of conducting studies on the new process for extracting TS oil and TS starch from tea seed focus on two aspects as follows. Firstly, there is 1.6 million hm² tea gardens in China and 84 million kg tea seeds are produced every year in these tea gardens. Ten million kg of TS oil which is worth 68.6

million U.S. dollars can be produced from 84 million kg of tea seeds [2]. However, great mass of the seeds are naturally rotted away in tea gardens because there is no better technology used for extracting oil and starch from tea seeds. Secondly, according to United Nations Food and Agriculture Organization (UNFAO), in the last 10 years tea consumption increased by 1.4% and tea yield increased by 1.9% in the world. It means that the increase of tea yield is greater than that of tea consumption and tea supply has exceeded demand continually for 10 years. The export unit price of tea has also declined under production cost of tea farmers [3]. Therefore, the tea gardens which only produce tea are facing potential risk of deficit. The important one of the ways to avoid the risk is also producing tea seeds used for extracting TS oil and TS starch while tea is produced in a tea garden. When tea market is not good, tea farmers can obtain income from tea seeds, and the precondition of obtaining income from tea seeds is that a better production process for extracting TS oil and TS starch is set up. In this study, the authors developed a new and better process of extracting TS oil and TS starch.

Corresponding author: Jinzhong Jiang, professor, research fields: development and utilization of tea seeds, genetics and breeding of tea plant. E-mail: jjz9911@163.com.

2. The Shortage of Existing Technology for Extracting TS Oil

There are five types of existing processes for extracting TS oil in China so far: heat squeeze, cool squeeze, solvent extraction, water-enzyme extraction and supercritical CO₂ extraction. They have some shortages, respectively.

(1) Heat squeeze

Tea seeds contain about 18% starch, heating in heat squeeze makes the starch dextrinized. The dextrinized starch impedes TS oil being squeezed out from tea seeds so that a part of oil is retained in the residue, leading to lower oil yield.

(2) Cool squeeze

Tea seeds contain about 20% protein, and the majority of TS oil is wrapped by protein resulting oil bodies. If protein is not denaturated by higher temperature, it is difficult for TS oil to outflow from oil bodies. Therefore, oil yield in cool squeeze is also lower, which is the reason why there are little TS oil to sell in market while tea-oil oil extracted from the seeds of tea-oil (*Camellia oleifera* Abel) seeds can be bought everywhere in the market.

(3) Solvent extraction

Solvent extraction has a higher yield rate of oil. But in the process, more energy is consumed, solvent recovery is difficult, solvent residue makes oil toxic, and the production cost is higher. The solvent residue makes consumer dislike the TS oil extracted by the process. In addition, because the most part of solvents used in the process are flammable and combustible materials, there are prodigious potential risks in the process running.

(4) Water-enzyme extraction

The process is not immature in TS oil extraction yet and many concrete technology details are being studied with test tubes in laboratory. Meanwhile, the process needs many types of enzyme and a great quantity for one type. Because of the expensive price of enzyme, the cost of TS oil production is higher.

(5) Supercritical CO₂ extraction

As solvent extraction mentioned above, the oil yield rate of this process is the highest among all processes mentioned above. Nevertheless, the equipment investment for the process is very high, the operation technique for running the process is difficult, and the production cost is higher, so that it is very hard to popularize and apply the process in practice. Therefore, there is not one supercritical CO₂ extraction production line maturely used for TS oil extraction in China yet, and also in other countries.

3. The New Process for TS Oil and TS Starch

In consideration of existing problems in TS oil production processes mentioned above, the authors began to study on the TS oil extraction process in 2011 and found that starch and protein in tea seeds were the key factors that impact oil production rate of tea seeds. Based on the findings, an imagine was built that it is possible to isolate starch and oil-protein complex (oil body) from tea seeds initially and then isolate TS oil from oil body, which can avoid undesirable impacts from starch on TS oil extraction. Through many tests a new and unique process for TS oil and TS starch extraction was developed (Fig. 1, in patent application in China, application number: 201310293420.9; 201310293224.1). Because there is a key link (static fermentation) that does not exist in other TS oil extraction process mentioned above, the authors named the new process as fermentation process. By the fermentation process, the authors extracted successfully TS oil and TS starch simultaneously. TS oil and TS starch production rates are 16% and 8%, respectively, and the extracted TS oil and TS starch have no any disliked smells and are completely in conformity with government standards for edible oil and starch.

According to Fig. 1, the fermentation process can be divided into five parts. Part 1 (static fermentation) includes tea seed soak, grind into thick liquid and static fermentation. Part 2 (separation) includes top layer, middle layer and bottom layer separate. Part 3 (oil

Fig. 1 The unique new production process for TS oil and TS starch.

production) includes boil, oil emerge, crude oil, refining and finished oil. Part 4 (tea saponin production) includes filter, flocculant deposit, ethyl alcohol extraction, finished tea saponin. Part 5 (starch production) includes crude starch, wash and filtrate, and finished starch.

Part 1: static fermentation.

Initially, shell of tea seeds was separated with husking machine specially meant for tea seed. Then endopleura of seeds were removed from seeds (Fig. 2a), the seeds without shell were soaked in water of 25 °C for 12-16 h. After that, the seeds without endopleura were grinded using water into thick liquid (Fig. 2b) with soybean milk machine, with 1.7/1 of liquid/solid (v/v). The particle size in the thick liquid was less than 100 mesh; the lesser the particles were, the better the effect was. The thick liquid was filtered with 100 mesh filter cloth resulting filtered liquid. Finally, the filtered liquid was poured into beaker and the beaker was placed in incubator, keeping temperature between 35 °C and 45 °C, naturally fermenting for 10-24 h. When fermentation went normally, the fermented liquid was divided naturally into obvious three layers (Fig. 2c): milky white top layer, deep yellow middle layer and white bottom layer.

Part 2: separation of fermented liquid.

Initially, fish out white top layer with a ladle made with 100 mesh hardware cloth, putting it into another beaker. Then, pour out the deep yellow middle layer carefully and slowly. Finally, leave white bottom layer in primary beaker.

Part 3: oil production.

Milky white top layer consists of oil bodies and water. Oil body (term in botany) is made of oil and protein, two kinds of materials combining closely. By

heating or protease action, these two materials can be separated from each other. In the test, the authors selected heating. Initially, milky white top layer was put onto iron pan (Fig. 2d), heating by induction cooker or other heater, stirring constantly as heating continually in order to avoid the oil body being burnt and promoting the evaporation of water in milky white top layer. Water got evaporated and oil flowed out of oil bodies as temperature rose more than 100 °C (Fig. 2e). By collecting this oil, TS oil in crude form was produced (Fig. 2f). Crude oil was refined by means of special equipments resulting in finished oil that is in conformity with Chinese state criteria about edible oil.

Part 4: tea saponin production.

Deep yellow middle layer contains tea saponin and other soluble materials. To get pure tea saponins, it is necessary to separate tea saponins from other soluble materials. Initially, flocculant ($\text{Al}_2(\text{SO}_4)_3$) was added into the deep yellow liquid. Tea saponins combined with flocculant resulting complex of them, which deposited by means of static state, and by filtering, the deposited complex was taken out of the liquid. Then, the deposited complex was put into 95% ethyl alcohol, refluxed, and decolorized by activated carbon. Then the ethyl alcohol solution was filtered and heated to evaporate resulting in dry tea saponin (Fig. 2g).

Part 5: starch production.

White bottom layer consists of starch and other soluble materials, such as soluble sugars, tea saponins and so on. To make the starch more pure, Pure water at 45-55 °C was poured into beaker in 1/5 of starch/water (v/v), stirring enough then keeping static to deposit. The deposited starch was taken out after depositing enough. To clear away other soluble materials from starch, the washing process was

repeated more than five times. Finished starch (Fig. 2h) was produced after the repeated washing process ended. The finished starch was in conformity with Chinese state criteria about edible starch.

4. Summary and Discussion

4.1 Advantage of the Production Process

Compared with all of the reported TS oil and TS starch production processes, the authors' production process has many advantages. In the entire production process, no chemical agents are added, which makes the TS oil and TS starch totally natural and free from contamination. Therefore, the products are safe as food. The production process does not require any squeezing.

It separates starch first then protein-oil complex, and finally oil from the protein-oil complex, which gets rid of adsorption and interference effects from starch and other constituents of tea seed. As a result, the oil extraction rate is higher and the pigment content in crude oil is lower, which makes subsequent processes more convenient. The production process and its equipments are simple, and the energy consumption and production cost are lower, which lead to the production process being popularized easily in mountainous/hilly areas where conditions are simple and crude. The production process can produce TS oil, TS starch and tea saponins at one time, which increases enormously the development and utilization value of tea seed.

Fig. 2 The process for production of tea seed oil and starch. (a): endopleura was removed; (b): thick liquid; (c): three layers of fermentation liquid; (d): top layer was heated; (e): TS oil flowed out; (f): crude TS oil; (g): dry tea saponin; (h): dry TS starch.

4.2 The Research Status of TS Oil and TS Starch Production Processes (in China)

As mentioned above, there are five types of existing processes for extracting TS oil in China. The research status of them are discussed as follows. It is reported in China that the main equipments used in heat squeeze and cool squeeze processes are double helix presser, and by the presser, crude TS oil can be extracted from tea seeds with about 6% oil-residual rate in dregs expelled from presser [4], so oil production rate of the process is lower. But these two production processes are the only processes that are used for commercial production of TS oil recently in China.

About solvent extraction, Luo et al. [5] indicated that TS oil production rate reached at 31.23% by Soxhlet extraction method using normal hexane as solvent, under 75 °C of extraction temperature and 1/12 of solid/liquid (g/mL). With respect to water-enzyme extraction, Wang et al. [6] indicated that TS oil production rate reached at 23.8% with a process condition that included 60 U/g of dosage of enzyme (cellulase), 1/5 of solid /liquid (g/mL), 60 °C of enzymolysis temperature and 3.5 h enzymolysis. Wang et al. [7] have studied on supercritical CO₂ extraction process for TS oil production, and indicated that TS oil production rate was 29.2% under these extraction conditions: temperature of 45 °C, 89.7 min and 32 MPa pressure. Xiao et al. [8] proposed a TS starch production process that raw material was grinded into 60-80 mesh, grinded material was soaked in 48 °C water for 3.7 h with 6.9/1 of liquid/solid (mL/g), at pH 9 and treated by ultrasound for 40 min, resulting 81.93% of TS starch extraction rate (amount of extracted starch contrasts total starch involved in tea seed).

From the aforesaid references, it can be seen that TS oil was extracted directly from complex of tea seed constituents in existing processes. In the paper, the authors reported a new phenomenon firstly found by

them, that is, filtered thick liquid from ground tea seeds can ferment naturally and the fermented liquid become three layers naturally after fermentation. The natural layering makes it easy to separate protein-oil complex (oil body) from tea seeds. So it is from oil body of tea seed that the authors extracted TS oil other than from complex of tea seed constituents as other precesses did. It can avoid undesirable impacts from starch and other materials on TS oil extraction, which make oil and starch production rate higher, and also make the further refining of crude oil done more easily.

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References

- [1] L.X. Zhou, Study on development and utilization of tea seed from Yunnan big leaf tea, *Yunnan Journal of Animal Science and Veterinary Medicine* 17 (1) (1995) 24-26.
- [2] Y.Q. Ma, Z.Z. Zhang, Research advance in comprehensive utilization of tea seeds, *China Oils and Fats* 35 (9) (2010) 66-69.
- [3] X.G. Wang, The four reasons about striving to develop tea seed oil industry, *Academic Journal* [Online], 2012, [http: /www.cnki.net](http://www.cnki.net).
- [4] W.G. Wu, Study on the tea seed oil producing and refining technique, *Journal of Tea Business* 33 (3) (2011) 131-133.
- [5] Y. Luo, X.P. Hu, C. Zhang, R. Xiao, Study on solvent extraction method of crude tea seed oil, *Food and Nutrition in China* 18 (4) (2012) 64-66.
- [6] X.Q. Wang, Study on aqueous enzymatic extraction of tea seed oil and tea saponin, *Journal of the Chinese Cereals and Oils Association* 26 (11) (2011) 76-78.
- [7] Y.F. Wang, S. Dao, H. Chen, L.S. Qian, P. Xu, Fatty acid composition and antioxidant activity of tea (*Camellia sinensis* L.) seed oil extracted by optimized supercritical carbon dioxide, *Int. J. Mol. Sci.* (12) (2011) 7708-7719.
- [8] L.Y. Xiao, H.L. Zhang, Y.T. Qi, W.N. Zhang, Study on extraction of tea seed starch, *Science and Technology of Food Industry* 32 (10) (2011) 8-12.