Recovery and Treatment of Garlic Oil from Garlic Slices Processing Wastewater

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Abstract. China is a big producer and exporter of dehydrated garlic slices. A large amount of garlic slices processing wastewater was produced every year, which contains garlic oil. In order to recycle and utilize this resource, this paper takes the local garlic slices processing wastewater in Jinxiang County of Shandong Province as the research object, and through "Microfiltration (MF)+Distillation". The method of distillation was used to extract garlic oil from garlic slice processing wastewater, and the effect of garlic slice cleaning process on garlic oil yield in wastewater was investigated. The results showed that the yield of garlic oil could reach 0.45‰ under the optimum cleaning conditions.

Introduction

Garlic slices is an important export agricultural product in China while a large number of processing wastewater are produced in the cleaning process of garlic slices. The discharge of the processing wastewater not only causes great harm to the environment but also seriously restricts the sustainable development of China's garlic industry [1]. The processing wastewater can also cause serious damage to the creatures and the environment. The main components of the garlic oil that cause environmental pollution are the garlic polysaccharides, the allicin and other organic compounds that are of economic value[2]. It is estimated that 17 to 20 tons of water to process per ton of garlic slices and there are 3.36 million tons of processing wastewater of garlic slices each year with the loss of about 30000 tons of garlic polysaccharide and 120 tons of the allicin [3]. The treatment technology of the processing wastewater of garlic slices is still in the research stage.

At present, the treatment technology to processing wastewater of garlic slices is still at the stage of study, and there is less research on extracting garlic oil from processing wastewater of garlic slices. Existing extraction methods include organic solvent extraction[4] and resin adsorption[5]. The method of resin adsorption is a new type method of water treatment. It has innovative significance in the extraction of garlic oil, but due to the complex operation and high production costs, it has not been promoted. This experiment summarized existing experimental data, and comprehensively considered various influencing factors, and selected suitable experimental methods to extract garlic oil from wastewater.

The garlic oil has antibacterial anti-inflammatory, improve immunity, anti-cancer and other anti-cancer effect, with high medical and health value[6]. In this paper, the experimental study of extracting garlic oil from garlic waste water can extract valuable resources from waste water, and the cost is low, so it has huge economic and social benefits.

Materials and Methods

Experimental Principle

Garlic oil is a kind of yellow oily liquid with a strong spicy flavor that is insoluble in water and
glycerol and not completely soluble in ethanol. The garlic that is unstable will continue to decompose into other products under the action of alliinase if long placed[7] . Therefore, it is necessary to choose the best garlic slice cleaning process, change the discharging rule of garlic slice water appropriately, and prevent garlic oil from oxidizing and decomposing in wastewater, so as to keep garlic oil content in wastewater at a high level. Because the boiling point of garlic oil is slightly lower than that of water, garlic oil in wastewater can be extracted by distillation.

Materials and Instruments

Processing wastewater of garlic slices (The pH of weak acid is provided by Shandong Jinxiang Garlic Factory.), Filter bag (the pore size of 5 μm is purchased from Shanghai Increased Micro-filtration Materials Co., Ltd.), DZTW Type Electronic Temperature Regulating Electric Heating Sleeve (Purchased in Beijing Yongguang Medical Instruments Co., Ltd.), Volatile oil extractor (Including: 1000 ml hard round bottom flask; 5 ml volatile oil extractor with minimum fraction of 0.1 ml; 400 mm spherical reflux condensation tube with effective length; purchased from Tianchang Science Instrument Experimental Equipment Co., Ltd.).

Experimental Process

As shown in Figure 1, the cleaning process of garlic slices produces a large amount of processing wastewater abundant in garlic oil. And the garlic oil productivity of the processing wastewater is measured to investigate the effect of the cleaning process of garlic slices on the extraction of the garlic oil in the experiment.

Experimental Design

According to the Appendix XD of Chinese Pharmacopoeia 2015[8], the instrument and apparatus for the determination of volatile oil were established. The garlic oil in garlic wastewater was extracted by distillation. A 1000ml volatile oil extractor was selected as the experimental instrument. The experimental steps are as follows:

Sample the wastewater, then use a 5-micron filter bag to pretreat the wastewater and remove the waste residue. Take 600 mL of Micro-filtered wastewater is added to the hard round-bottom flask with a capacity of 1000 ml, and the flask is put into the electric heating jacket to connect the power supply. Connect the volatile oil determinator with the reflux condensation tube. In order to facilitate garlic oil collection and observation, the volatile oil determinator is filled with water and can flow back to the flask. The distillation flask was heated by adjusting the heating voltage to 220 V. The heating voltage was reduced to about 110 V after the solution boiling. The experimental phenomena were observed. The oil output was recorded after 5 minutes, and then the oil output was recorded every 10 minutes, and the heating was stopped after the oil output was stable. In order to eliminate the interference factors, the experiment was repeated 2-3 times, and the average value was taken for statistics.
Analysis of the Garlic Oil Productivity

The garlic oil productivity from the processing wastewater of garlic slices is calculated using Eq. (1):

\[ c = \frac{V}{V_0} \times 100\% \tag{1} \]

where \( V_0 \) is the volume of the sample placed in the round bottom flask and \( V \) is the volume of the garlic oil measured in the volatile oil measuring tube.

Experimental Results and Discussion

Garlic Oil Productivity of Random Samples in Factory A

The garlic slice cleaning pond in factory A is 2.2 m long and 1m wide. The garlic slice cleaning process is irregular water intake and drainage, so as to keep the water depth around 1m. Because the garlic oil content in garlic slice cleaning wastewater is very low, in order to explore whether the volatile oil extractor can be used as garlic oil extracting device in garlic slice cleaning wastewater, garlic slice cleaning wastewater in factory A is used as raw material, and the wastewater in garlic slice cleaning pond is randomly taken. The experimental data of garlic oil extraction are shown in Fig. 3. It can be seen from the figure that garlic oil can be extracted from garlic slice cleaning wastewater by using volatile oil extractor, but garlic oil is unstable, garlic oil yield can reach 0.33‰.

On one hand, the size of the washing pool in Factory A results in a long time when the part of the garlic oil in the processing wastewater remains in the washing pool, which can cause the decomposition of the unstable allicin in the garlic oil. Therefore, the content of the garlic oil in the processing wastewater may change with the time and the garlic oil productivity with the samples randomly taken is not stable.
Garlic Oil Productivity of Samples at Equal Time Intervals in Factory A

The garlic oil productivity with the samples at equal time intervals in Factory A is shown in Figure 4 with the irregular inflow and discharge of the cleaning water of garlic slices and the samples taken from the washing pool of garlic slices every one hour after the start of the cleaning water production. As shown in Figure 4, with the increase of cleaning time of garlic slices, the garlic oil productivity does not change regularly. The highest garlic oil productivity of 0.33‰ at the time of 8 hours.

![Figure 4. The garlic oil productivity with the samples at equal time intervals in Factory A.](image)

The irregular inflow and discharge of the processing wastewater of the garlic oil can lead to the change of the time when the garlic oil remains in the washing pool, which can cause the difference of the decomposition degree of the unstable allicin in the garlic oil. Therefore, the original cleaning process in Factory A is not suitable for the garlic oil extraction from the processing wastewater of garlic slices.

Effect of the Cleaning Process of Garlic Slices on Garlic Oil Productivity in Factory A

In this experiment, the cleaning process for garlic slices is recycling the garlic cleaning water of garlic slices for 2 hours and then discharging the garlic cleaning water. Because more than 2 hours, the cleaning water in the pool is too cloudy, which will affect the production quality of garlic slices. Samples are extracted at the time of 1 hour and 2 hours after the experiment began with the fresh cleaning water, respectively. And the garlic oil productivity of the samples is measured twice and the average of the garlic oil productivity is obtained as the value of the garlic oil productivity each sample.

![Figure 5. The garlic oil productivity with the garlic cleaning water recycled for 2 hours and then discharged.](image)

As can be seen from Figure 5, the garlic oil productivity with the garlic cleaning water recycled for two hours is higher than that for one hour, which is due to the accumulation of garlic oil with the time increasing. The maximum of the garlic oil productivity reaches 0.45‰ and the garlic oil productivity with the garlic cleaning water recycled for one hours and two hours are both relatively stable.

Experimental Results Analysis

When garlic oil was extracted from garlic slice cleaning wastewater of factory A by random sampling, the experimental results showed that the garlic oil yield in wastewater was obviously unstable. The garlic oil yield in wastewater sampled at equal intervals did not change regularly.
After changing garlic slice cleaning process of factory A, garlic oil yield in wastewater was relatively stable when garlic slice cleaning process was changed for 2 hours. So this process could replace the original garlic oil yield. Washing process of garlic slices. The garlic slices are cleaned and the yield of garlic oil in wastewater is guaranteed. Compared with the research done by others in the industry to extract garlic oil from processing wastewater of garlic slices[5], this experimental operation method is more simple, and the garlic oil productivity can still be maintained at a high level.

Conclusion
The experimental results showed that garlic oil was extracted from garlic slices processing wastewater by distillation. The optimum technological conditions for garlic slices cleaning are: cleaning water for 2 hours without entering or discharging. The quality of dehydrated garlic slices produced is normal, and the yield of garlic oil in wastewater can reach 0.45‰, and the garlic oil content is relatively stable under this cleaning process. The treatment method of garlic oil extraction from wastewater not only makes garlic slice processing wastewater effectively treated, but also effectively alleviates the problem of water pollution and protects the environment. It also makes the precious garlic oil resources recycled, promotes the modernization of agriculture, and generates income for farmers, with great social and economic benefits.

References