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Progress in the Study of Pineapple Bran Vinegar

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Abstract. Currently, pineapple bran vinegar is divided into two types - blended and fermented. Fermented pineapple bran vinegar is formed by using pineapple bran as its main raw material which is fermented by both alcohol and acetic acid. This vinegar can be used as both flavoring and beverage. This paper introduced pineapple bran's nutritional properties, current processing and utilization status and fermentation process of pineapple bran into vinegar, summarized the progress in the study of fermented pineapple bran vinegar, probed into the problems of current production process and the measures to resolve them and demonstrated the broad prospect to develop fermented pineapple bran vinegar.

1. Introduction

As a new kind of health drink, fruit vinegar is popular with broad masses of consumers because of its rich nutrition, unique flavor and excellent taste. Fruit vinegar is one of the acidic seasonings with rich nutrition and good flavor. It uses fruits or by-products formed when processing fruits as its main raw material which is fermented by both alcohol and acetic acid, so bringing its properties of high nutrition, strong acetous smell and soft sour. Fruit vinegar retains most of the original nutrients in the fruits and possesses the functions of common vinegar's disease prevention and curing, body building and recovery from sickness [1]. Compared with food vinegar, fruit vinegar is richer in nutrients and its health-care performance is also better than food vinegar's [2]. Its rich acetic acid, succinct acid, malic acid, citric acid, amino acids, vitamins, bioactive substances and so on [3] can eliminate fatigue, lower blood pressure, resolve blood cholesterol, prevent the happening of both arteriosclerosis and cardiovascular diseases, increase appetite, and protect skin and etc. [4]. In addition to being used as condiment, fruit vinegar can also be made into acetic acid. At present, the market is dominated by apple vinegar, also jujube vinegar, pear vinegar, persimmon vinegar and others [5], but pineapple vinegar and pineapple bran vinegar are rarely seen. Pineapple bran vinegar is a kind of vinegar beverage by using pineapple bran as its main raw materials after being blended or fermented, so is very rich in both amino acids and trace elements essential to human body and can appetizers, invigorate the spleen, build up a good physique and improve one's health.

2. Overview of Pineapple Bran

Pineapple is a tropical and subtropical fruit which is mainly grew in subtropical areas such as Guangdong, Hainan, Guangxi, Fujian and Yunnan. It is not only brightly colored, but also sweet and fragrant. Because of the fact that pineapple is not easily stored, few fresh fruits are eaten as food and most are used in canned food and juice processing and bran left when processing account for over 40% of the whole fruit weight. According to statistics, only a small amount of pineapple bran are processed to low-value feed and more than 70% are discarded, causing a huge waste of natural resource and a serious pollution to ecological environment. Pineapple bran has as rich juice and flavor as pineapple fruit and contains rich sugar, protein, vitamins and a variety of nutrients essential for microorganisms to grow. Analysis and test showed that the percentages of water, citric acid, total

sugar and so on contained in pineapple bran are similar to those of pineapple pulp and the contents of crude protein and ash are even higher than those of pulp, respectively 2.5 times and 2.5 times those of the latter [6], and that can be utilized for microbial growth and are an ideal raw material to make fruit vinegar.

There have been various studies on the comprehensive utilization of pineapples in China, but there are few [7] that can be converted into productive forces at the right time. In view of pineapple bran's low utilization rate where most become processing factories' waste and pollution sources, low efficiency of pineapple processing industry and so on, it would have significant importance to start the research of key technology for fermenting pineapple bran into fruit vinegar, develop aged fruit vinegar with commercial value from high-quality pineapple bran, improve the comprehensive utilization of the by-products from processing of pineapple, enhance the added value of pineapple processing, and solve the prominent industrial problem of resource waste and environmental pollution.

3. Progress in the Study of Fruit Vinegar Fermented from Pineapple Bran

Currently, pineapple bran vinegar mainly includes two types: blended and fermented. Fermented vinegar is made mainly from pineapple bran as its raw material which is fermented first by alcohol and then by acetic acid. Blended pineapple vinegar means it is mixed by pineapple bran juice and vinegar in a certain proportion and then blended with a certain amount of cane sugar, rock candy, and honey and so on. This paper introduces the production process and study status of fermented pineapple bran vinegar.

3.1 Production Process of Fruit Vinegar Fermented from Pineapple Bran.

Production process of fermenting pineapple bran into vinegar is as follows: Pineapple Cleaning -> Hot-water blanching -> Peeling -> Crushing -> Sweetness and sourness adjustment -> Alcoholic fermentation -> Acetic-acid fermentation -> Filtration -> Aging -> Blending -> Sterilization -> Cooling -> Packing -> Finished product.

Raw material should be fresh pineapple with 80% maturity and without rot. Why does it need aging? Newly brewed vinegar has a strong aroma but with less soft flavor, so vinegar must be put in an airtight container and aged at room temperature for more than one month by avoiding contact with oxygen to improve the quality and flavor of vinegar. Also, as the vinegar is being aged longer and longer, the ketones contained in vinegar will become less gradually, but acids, alcohols and esters will be increased to some extent. The slow reduction of ketones can eliminate some bad odor and make the flavor of vinegar softer.

3.2 Status in the Study of Production Process of Fruit Vinegar Fermented from Pineapple Bran.

At present, the fermentation process of pineapple into vinegar can be divided into liquid-state, semi-solid and solid-state fermentations. Research of the production process mainly focuses on two aspects: Selection of the yeast fermenting pineapple bran into vinegar and establishment of the fermentation process. In recent years, our study on the process of fermenting pineapple into vinegar has made a lot of achievements.

LAN Wei, el at.[8] brewed vinegar by adopting liquid-state spraying process and using pineapple bran as acetic acid bacteria carrier. Its main processes included: Crushing (cutter mesh size was 12 mm) -> Adjustment of sugar and acid contents (contents of sugar and citric acid added were calculated according to the expected acidity of end products) -> Ethanol fermentation (active dry yeast - its addition was 0.05% of the raw material) -> Acetic acid fermentation (active acetic acid bacteria - its addition is 0.05% of the raw material) -> Aging (in airtight containers for one months or so) -> Clarification (3# clarifying agent - its addition was 2.5%) -> Filtration -> Sterilization (60~70℃ for 30 minutes). The fruit vinegar made from this process was clear and transparent and looked amber with rich pineapple aroma and soft sour.

SHANG Yunqing, el at.[9] adopted single-factor experiment to determine the production process of acetic acid fermentation which used pineapple bran as raw material. The result showed that the

optimum process condition for fermentation was 33℃ with an initial alcohol content of 8% and inoculum dose of 10%. Acetic acidity of vinegar fermented in this condition was above 3% with better vinegar flavor and taste.

WU Bin, el at.[10] studied the effect of pectinase on acetic beverage fermented from pineapple with pineapple bran as its raw material during the alcoholic fermentation stage by using contents of both sugar and alcohol as indicators and the effect of aeration on acetic beverage during acetic fermentation stage by using content of acetic acid as indicator. The results showed that (1) Pectinase did not affect the result of acetic fermentation significantly; (2) Inflation as a method of oxygenation could improve the efficiency of acetic fermentation effectively. After washing and hot-water blanching, pineapple bran was shredded and juice was extracted, then sulphurous acid (expressed in SO_2) was added with its concentration to be 0.3%. Then the liquid-state alcoholic fermentation method was used and yeast was inoculated with a concentration of 10% and mixed evenly. Temperature was controlled at 33℃ and pineapple bran was stirred 2 to 3 times a day. When the alcohol content reached 5-7%, the mother liquid of acetic acid bacteria with a concentration of 10% on which activation and inoculum development were already performed was added to the wine and mixed evenly, then flask was shook for ventilation for better acetic fermentation. Fermentation temperature was still kept at 33℃. Six days later, the concentrations of acetic acid fermented by inflation and bed shaking were 6.81% and 6.35% respectively. Pineapple vinegar made from fermentation had a unique flavor with ordinary vinegar's delicate fragrance and pineapple's fruity aroma. The concentration of acetic acid in vinegar fermented by inflation during the acetic fermentation was higher than that by bed shaking.

FU Zhenhua, el at.[11] developed pineapple vinegar by mixed-yeast fermentation. After juice was extracted from pineapple bran, its residue was added with yeast and lactic acid bacteria for alcoholic fermentation at 22℃. When alcohol content stopped rising, acetic acid bacteria was added for acetic fermentation at 30℃ with full ventilation. When acid contents stopped rising, acetic fermentation was stopped and vinegar was aged at 18-20℃ for 30 days. The physical and chemical indexes of pineapple vinegar such brewed included a total acid of 4.52g/100mL (in acetic acid) and a reducing sugar of 1.58g/100mL. Gas chromatography and mass spectrometry were used for test and analysis of the vinegar which centrifugation and filtration were carried on and was blended for a concentration of 2%. The result showed that the vinegar contained 36 flavors, including 13 volatile components and 23 nonvolatile components. The combined action of these substances brought pineapple vinegar unique flavor.

LI Nanwei, el at.[12] studied the fermentation process of pineapple bran into vinegar by comprehensive consideration of vinegar's acetic acid content and sensory evaluation. This fermentation's optimal process conditions included: juice extraction rate would be the highest if pectinase addition was 200mg/L. For alcoholic fermentation, the initial sugar degree was controlled at 16°Bx with an inoculum concentration of 11%, a fermentation temperature of 18℃ and a fermentation time of three days. For acetic fermentation, its optimal conditions included an initial alcohol content of 12%, an inoculum concentration of 12%, a fermentation temperature of 29℃ and a fermentation time of four days. Accordingly the vinegar such brewed tasted soft and fruity with moderate sweet and sour.

GU Caiqin, el at.[13] studied the fermentation process of pineapple bran into vinegar by semi-solid method. This method used pineapple bran as its main raw material, fruit-wine yeast and Huniang 1.01 acetic bacteria powder as its microbial strains and semi-solid fermentation and secondary sugar supplementation as its processes to define its optimal brewing process parameters. The results showed that for alcoholic fermentation, its optimal conditions included a yeast addition of 0.3%, a fermentation temperature of 22℃, a sugar degree of 16°Brix, a pH of 3.5, and a fermentation time of 6 days; for acetic fermentation, the best process conditions included a glucose addition of 2%, an initial ethanol fraction of 8% (in volume), a fermentation temperature of 29℃, an acetic bacteria powder addition of 0.09%, and a fermentation time of 3~4 days. Finally, a semi-solid mixture of pineapple vinegar with a total acid (acetate) content of up to 6.78g/100g was formed with an acetic

acid conversion rate of 82.5%. After soaking, filtering and aging for 1~2 months, the final product of pineapple vinegar with a total acid content (acetic acid) of 3.672g/100ml was formed which looked golden, clear and transparent with both acidic aroma and pineapple's fruity aroma and also soft and refreshing taste.

WANG Ling, el at.[14] used alcoholic fermentation with pineapple bran as its raw material and multi-strain mixture as yeast to make the vinegar. Single-factor experiment on the vinegar such brewed found the optimal process conditions for acetic fermentation. The results showed that the vinegar such fermented from pineapple bran owned prominent fruity and winy aromas. When fermenting at a temperature of 33℃, an initial wine degree of 6% and an inoculums concentration of 10%, the vinegar's acetic acid degree could reach 4.8% or more. The pineapple vinegar such brewed possessed full-bodied aroma and soft sour.

3.3 Problems with the Production Processes of Fermenting Pineapple Bran into Vinegar.

The acetification process which uses pineapple bran to make fruit vinegar may adopt solid-state fermentation which adds wheat bran, rice husk ash, rice chaff, etc. as supplements. The vinegar made from this process owns good flavor but with longer fermentation time, too more waste and higher labor intensity. In most cases, traditional fermentation process which uses soaking, spraying, and other liquid-state fermentation processes adopts single yeast for alcoholic and acetic fermentation but with long acetification time of 8~18 days. Another method which uses solid-state fermentation first during alcoholic fermentation and then liquid-state fermentation during acetic fermentation was studied. Its acetification time can be shortened by 4~5 days, but generally, liquid-state fermentation's requirements for equipment are higher, so the investment is higher, and also vinegar's fruity aroma is not prominent, sour is not soft enough, taste is poor, flavor is insufficient, etc. Currently, some are using liquid-state mixed-bacteria fermentation to make pineapple vinegar, trying to solve the problems of pineapple vinegar's insufficient flavor made by liquid-state method. But, it stays only at the research stage now.

Additionally, a study was reported which used semi-solid fermentation and secondary carbon source supplementation to make vinegar from pineapple bran. Its basic fermentation materials are peel and residue with a small amount of fruit juice. Pineapple bran was used as the carrier of acetic acid bacteria to form a loose environment for acetic fermentation, thus satisfying the demand of acetic acid bacteria on oxygen. The optimum carbon source for acetic acid bacteria is glucose, fructose, and other hexoses. Yeasts' competition for nutrients extended vinegar's fermentation time, which indicated that supplementation of carbon source to a mixture of wine in time after alcoholic fermentation can shorten acetic fermentation time. Compared with liquid-state fermentation, semi-solid fermentation may increase yield of total acid and shorten fermentation time significantly. But studies have not yet been reported on how to shorten acetic fermentation time and increase the yield of acid by carbon source supplementation.

Therefore, it would be of high research value by studying solid-state and liquid-state microbial vinegar fermentation and processing technology, optimizing the existing fermentation process, performing a comprehensive analysis of various influencing factors during fermentation, and exploring a kind of method brewing pineapple bran into vinegar which can not only shorten fermentation time with high acid yield but also make vinegar with better flavor, less investment and convenient operation.

4. Summary

As people's living standards are improving unceasingly, fruit vinegar's health care function is also more and more valued and an upsurge to drink fruit vinegar is being seen in China, and accordingly studies on vinegar-fermenting yeast, processing technology and blending method are more and more favored. Pineapple belongs to a kind of tropical fruit with high seasonality and is not easy to store at room temperature because of easy decay and deterioration. Now, pineapple bran's by-products are mostly discarded as processing waste. Pineapple bran contains a variety of vitamins and amino acids with rich nutrition and is suitable for brewing fruit vinegar. Pineapple resources are rich in China and

the development of pineapple bran into vinegar can add the value of pineapple fruit processing by 10% or more. This not only can improve the utilization and conversion rate of pineapple bran, but also realize the comprehensive utilization of limited natural resources by making waste profitable, achieve the efficient utilization of pineapple by-products, reduce resource waste, and ease the pollution of pineapple by-products on ecological environment significantly. In addition, it conforms to the developmental trend of condiment functionalization in both China and foreign countries. So, wide market prospect and high social and economic benefits can be found from it.

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