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The Effects of Tree Barks in the Fermentation of Sugarcane

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Abstract

Aim: This study primarily aimed to determine the effects of tree bark on the sensory and acidity level of sugarcane vinegar produced.

Methodology: The use of an experimental research design with three kinds of tree bark was utilized in making sugarcane vinegar. The study revealed that the vinegar produced using "Samak" tree bark has a more intense sour aroma than the vinegar produced without tree bark. It also has a darker brown color, consistent but comparable appearance, and turbidity. Furthermore, the kind of tree bark plays a significant role in the acidity level of the mash. The rate of fermentation can also be enhanced by the addition of tree bark, considering that tree bark favors faster alcoholic fermentation. Therefore, the "Samak" tree bark is the best used for vinegar fermentation and coloring agent. It is then recommended that vinegar producers will consider the type of tree bark that accelerate the fermentation, providing brighter color and enhancing the sensory qualities of sugarcane vinegar. Lastly, the research result will serve as a reference to local vinegar producers in the municipality to produce quality vinegar and to maximize the production process of the sugarcane industry in the province for the upliftment of the economic status.

Keywords: sugarcane; vinegar; tree bark; fermentation; evaluation; acidity.

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1. Introduction

Vinegar is the world's oldest cooking ingredient and food preservation method. The prevalent use of vinegar is due to its significant part in prolonging the shelf life of food and its uses in the kitchen. Almost all mouth-watering dishes need a teaspoonful or two of vinegar. It is even an ingredient for some cakes, souffles' and native delicacies. Reference [16] states that historically, vinegar has been used as a preservative or as an acid for cooking. Like some of the other foods we love, such as cheese, yogurt, and wine, vinegar is also made with the help of microorganisms that ferment sugars and convert them into acetic acid. Vinegar is a liquid consisting of about 5 to 20 percent acetic acid, water, trace elements, and, in some cases, flavorings. It has been used as a treatment for many different ailments since the time of Hippocrates, around 420 B.C. Diluted acetic acid by itself is not considered vinegar because vinegar contains other minerals, vitamins, and amino acids. Other bioactive products in vinegar include gallic acid, catechin, epicatechin, and caffeic acid.

Vinegar has been claimed to have several health benefits, which include, helping with digestion, using as an antibacterial balm to dress wounds, and treating dandruff and itchy scalp [8]. In food preservation, its uses are due to its low pH (potential of hydrogen) that retarded microbial growth, and contribution sensory properties to several foods. Aside from its preservative treatment, Filipinos also like the prominent flavor punch that vinegar can provide, thus, earning its niche in any Filipino kitchen. Moreover, it is a good source of income – a promising business venture for any Filipino interested in making more money at home.

According to the [14], the earliest known use of vinegar dated back more than 10,000 years ago has been used as food and medicine, and point out in the recent studies that different types of vinegar may benefit humans' health. Functional therapeutic properties include beneficial effects on cardiovascular health and blood pressure, antibacterial activity, reduction in diabetes, and increased vigor after exercise. Apple cider vinegar is claimed to increase satiety levels, meaning people who consume it will feel fuller for longer than those who do not. Because of this, it's often used as a tool for those looking to lose weight. Other claimed health benefits of drinking apple cider vinegar include, Fights Diabetes, Reducing belly fat, Lower cholesterol [18]

Moreover, see [5] also stated that both grain vinegar and fruit vinegar, which are fermented by traditional methods, possess a variety of physiological functions, such as antibacterial, anti-infection, anti-oxidation, blood glucose control, lipid metabolism regulation, weight loss, and anticancer activities. The antibacterial and anti-infection abilities of vinegar are mainly due to organic acids, polyphenols, and melanoidins. The polyphenols and melanoidins also provide the antioxidant abilities of vinegar produced from the raw materials and fermentation processes, respectively. Furthermore, although acetic acid was by far the predominant flavor present in vinegar, other volatile flavor compounds were also present that added to the overall flavor profile of vinegar. In addition to this, acetic acid, which gives red-wine vinegar and other vinegars their sour taste, helps you stay satisfied after eating by minimizing blood sugar spikes [7]

Colino [6] has argued that Grain vinegar and fruit vinegar, both of which are fermented, possess a variety of beneficial physiological effects, including antibacterial and antioxidant properties and even some anticancer activities (particularly with Japanese black soybean vinegar), according to a 2016 review in the journal

Comprehensive Reviews in Food Science and Food Safety.

Vinegar made from sugarcane juice is most popular in the Philippines, particularly in the Northern Ilocos Region (where it is called *sukang Iloko* or *sukang basis*), although it is also produced in France and the United States. It ranges from dark yellow to golden brown and has a mellow flavor, similar in some respects to rice vinegar, though with a somewhat "fresher" taste due to the presence of residual sugar.

In the Philippines, it is frequently used to manufacture a fermented drink made from sugarcane which also yields tannins. Tannins are polyphenolic biomolecules with carbohydrate backbones that are found in a wide range of plants. Tannic acid is a specific tannin that formally contains 10 galloyl (3,4,5-trihydroxyphenyl) units surrounding a glucose center. Commercial tannic acid, however, consists of molecules with 2–12 galloyl moieties. Tannic acid contains no carboxyl groups but is weakly acidic because of the multiplicity of phenolic hydroxyls. The hydroxyls also cause it to be extremely soluble in water. All regulatory authorities classify it as a nonhazardous substance [1]. The concentrations of TA and bleached shellac were used as the variables and the mass loss percentage and the incidence of black spots in mango fruit were used as the response values to optimize the formulation of the composite preservative using response surface methodology based on central composite design. Meanwhile, the physical and chemical indexes of the optimized formulation were tested. The results showed that the composite preservative could prolong the shelf life of mango fruit at room temperature. The optimal proportions (m/m) of the ingredients were 7.3% bleached shellac, and 0.3% TA. The mass loss percentage and the incidence of black spots in mango fruit treated with the optimized preservative were 24.38% and 29.91% after 18 days of storage, respectively. Compared with the blank control group, the preservative significantly reduced the loss of nutrients such as titration acid, soluble sugar, total soluble solids, and ascorbic acid in mangoes, delaying the decaying process, and prolonged shelf life by at least 8 days [17]. Moreover, sukang Iloko or Ilocano cane vinegar is from the Northern Region of Ilocos, a by-product of Ilocano sugarcane wine known as *basi*. It is made by cooking the cane juice to reach a molasses-like state. This juice is placed in clay jars together with the bark of a *duhat* or Java plum tree, then left to ferment into base wine, then eventually into vinegar. It has a deep, dark color with a mellow/rich flavor and a hint of sweetness [12].

Sugarcane juice cannot by itself become basi without “gamú ." Therefore, plant ingredients are fermenting and a coloring agent in basi/vinegar production. The plant used depends on the communities' or even individual families' practices.

Likewise, the Samak *(Macaranga tanarius*) tree appears to be utilized by most basi makers, with its dried leaves, bark, fruits, and primarily its flowers known as efficacious fermenting ingredients. Other materials for gamú include the bark of native Ipil *(Albizia lebbekoides*) and Duhat (Lomboy) in Tagalog; *Syzygium cumini*); bark and leaves of bayyabas (guava; *Psidium guajava L*.); branches and leaves of cards (pigeon pea; *Cajanus cajan*); pan-aw (cogon grass; Imperata cylindrical); and the locally-made yeast bubod, which is more associated with the southern towns of the region.

Samak is scientifically known as *Macaranga tanarius, Linn.* “Elephant ear” – is a small tree with a medicinal bark that uses the leaves and fruits in fermenting and coloring basi or vinegar and tuba in some places in Luzon.

For example, the making of sukang Iloco from sugarcane juice is fermented from Samak leaves and bark, traditionally left in jars to age, until it turns to vinegar when color and flavor become darker and perfectly stronger. In our home, it is often said that the darker, the better. In addition, [13] also stated that “Samak” leaves to dye the “basi” or “suka” make those famous Ilocos products 100% organic. To the Ilocano people, parasol leaf or “Samak” is an agent in making delicious vinegar. Vinegar has been an ancient food preservative; it is very important for its various culinary uses at home and in the food industry. It is needed to promote the safety of food and wellness uniwide as an essential part of food products [8].

Additionally, dried barks of the “kariskis” tree to ferment the sugarcane juice are also effective. [13]. *Albizia lebbekoides* is a tree that is usually growing eight to fifteen meters tall but sometimes up to 32 meters with a trunk of 40cm up to 80 cm. in diameter. Its bark is smooth, grey or greyish brown, and its living bark is beefy red. Moreover, it provides a red dye, formerly used in coloring cloth and known as "soga tekik” in eastern Java. Dye has also been extracted in Central America from the seeds, pods, and bark, and extraction methods for this potential dye have been conducted in Indonesia.

The use of organic fermentation for sugarcane vinegar is still practiced in the Ilocos Region, considering its availability and usefulness. Analysis of the different claims in the inconsistencies of the sugarcane vinegar characteristics, a study, therefore, is needed to prove or disprove such is very vital. Vinegar production previously studied was focused more on how to speed up the fermentation process but limited the use of tree bark on the quality of sugarcane vinegar produced specifically on its rate and the resulting sensory and physicochemical attributes. Though limited research was found, a verification trial was conducted to find its effectiveness and adaptability, concentrating on the different kinds of tree bark as a colorant and fermenting agent used by the traditional basi and vinegar makers in Ilocos.

Objectives: The purpose of this study is to determine if the different kinds of tree bark affect the physicochemical and sensory characteristics of sugarcane vinegar produced. Specifically, it aimed to determine if there is a significant difference in the effects of tree bark on sugarcane vinegar's sensory characteristics, the sugarcane vinegar's physicochemical properties in terms of acidity and Brix, and the implication of the result to the micro-small enterprises in vinegar production.

Hypothesis: The kinds of tree bark affect the sensory characteristics of sugarcane vinegar

2. Methodology

2.1 Research Design

The study used an experimental research design utilizing the Complete Randomized Design. Four treatments with three replicates were applied as follows: T0 (control), T1 (Duhat Bark), T2 (Native Ipil Bark), and T3 (Samak Bark). The sensory evaluation and physicochemical analyses of the vinegar produced were the basis for identifying the effects of sugarcane vinegar's different tree bark characteristics.

2.2 Population and Sampling

The four sample treatments were assessed by a panel of evaluators composed of 30 participants coming from faculty, students, and the buying public. The selection of faculty and student evaluators are limited to those who are teaching in the Hospitality Management and Teacher Education Departments and the makers of vinegar and consumers who are users of native sugarcane vinegar.

2.3 Procedure

The researchers prepared nine (9) plastic containers to accommodate 6 liters of sugarcane juice. These were cleaned thoroughly with soap and water and finally sterilized with boiled water and drain. The tree barks were gathered from the nearby areas, washed and cut into smaller pieces, and weighed to acquire the corresponding weight needed in each treatment. The sugarcane was extracted with the help of one vinegar producer in Maynganay, Sta. Maria, Ilocos Sur. Six liters of sugarcane juice were strained and placed in the designated container. The prepared and weighed tree barks were incorporated into each container and labeled with the treatment used in the experiment. Once done, the plastic containers were arranged in a storage area, and left the sugarcane juice underwent the fermentation process. The date wherein the fermentation started, and the date wherein the cane vinegar's 3-4% acidity level was achieved were also appropriately noted and tabulated. The fermentation rate was obtained by counting the actual number of days of the fermentation process. The samples were tested every month using the ph meter considering the acidity level. Sensory evaluation of the different treatments was made by 30 students, faculty, and consumers in a designated area at the end of the experiment. Evaluators were served with a glass of water to neutralize the taste before analyzing the following sample.

2.4 Data Gathering Instrument

The sensory evaluation sheet was distributed before the actual evaluation of the products. The instrument was discussed thoroughly to them to be able to understand the content of the evaluation sheet based on how the products were judged in terms of appearance, taste, aroma, color, turbidity, and consistency. The following scale were used as follows:

Scale	Description
4.21 -5.00	Very Much Acceptable
3.61- 4.20	Very Acceptable
2.41-3.60	Acceptable
1.81- 2.40	Less Acceptable
1.00-1.60	Not Aceptable

2.5 Ethical Considerations

Since food products were used for sensory evaluation, the products were undergone microbial analysis to determine whether the products were safe for human consumption. Ethical principles such as privacy, confidentiality, prevention of risk or harm, voluntary participation, and other humane treatments of the evaluators and consumers are essential in conducting the research.

2.6 Treatment of Data

Sensory evaluation of vinegar fermented with the use of tree barks was subjected to Quantitative Descriptive Analysis to determine their specific sensory characteristics. QDA is a technique in which individuals identify and quantify the sensory properties of a product or ingredient in the order of occurrence [19]. Identified attributes of vinegar with a significant difference are then subjected to consumer testing using the 5-point scale to determine the consumer perception of the sensory attributes identified, respectively. Samples for sensory evaluation were drawn using the pre-coded plastic cups after attaining the vinegar with 3-4% acidity. The student's faculty evaluated sugarcane vinegar and the consumers using the Likert Scale, where one (1) is the lowest and five (5) is the highest. Evaluators rated the products in appearance, taste, aroma, color, turbidity, and consistency. Data on the overall acceptability and purchase intention were also included. An interview was also asked the selected vinegar makers to determine the study's implication to the micro-small enterprises in the locality. Analysis of Variance (ANOVA) using the Tukey Kramer Test was used to determine whether the identified sensory characteristics from the quantitative analysis and the consumer test would differ significantly in using different tree bark as the fermenting agent. Served as the basis for identifying the type of tree bark used would affect the characteristics of the vinegar produced and hasten the fermentation of sugarcane vinegar.

3. Results

3.1 Sensory Evaluation of Sugarcane Vinegar

Various researchers characterized the quality of vinegar using different analytical parameters as well as sensory analysis. The sensory characteristics evaluated are; appearance, taste, aroma, color, turbidity, and consistency, which served as a basis for determining the effects on the sensory characteristics of sugarcane vinegar.

The sensory characteristics of sugarcane vinegar treated with “Samak" bark appeared the highest mean score of 4.46 in terms of appearance. Indicates that adding "Samak” bark to sugarcane vinegar during fermentation resulted in a very much acceptable appearance as perceived by the panel of evaluators. Analysis of variance indicated that there are significant differences existed between treatments. Further analysis using Tukey Kramer Test, however, proved a significant difference existed between T3 (Samak) vs. T0 (control) -T2 (Ipil), and no significant differences were observed between T0 vs. T2 combinations. This explains by the fact that the appearance of sugarcane vinegar treated with "Samak" appeared a reddish color to other vinegar treated with other tree barks. On the other hand, the sugarcane vinegar treated with duhat bark gives a blackish color that creates only an adequate evaluation. The evaluators preferred "Samak” to give a brighter color to the sugarcane vinegar. The use of Samak proved that sukang Ilocos is fermented from sugarcane juice and Samak leaves, were

traditionally left in jars to age. It is also attested that Samak was also used in sugarcane winemaking until it turns the appearance, color, and flavor become darker and perfectly stronger. Finally, it is said that the darker the vinegar the better [14].

Variable	Experimental Lot	Mean	Description
Appearance	T0 - Control	4.07[b]	Very Acceptable
	T1- Duhat bark	3.20[c]	Acceptable
	T2- native Ipil bark	4.15[b]	Very Acceptable
	T3- Samak Bark	4.46[a]	Very Much Acceptable
Taste	T0 - Control	4.05[b]	Very Acceptable
	T1- Duhat bark	3.54[d]	Very Acceptable
	T2- native Ipil bark	3.70[c]	Very Acceptable
	T3- Samak Bark	4.03[a]	Very Acceptable
Aroma	T0 - Control	4.05	Very Acceptable
	T1- Duhat bark	3.61	Very Acceptable
	T2- native Ipil bark	3.98	Very Acceptable
	T3- Samak Bark	4.19	Very Acceptable
Color	T0 - Control	3.98	Very Acceptable
	T1- Duhat bark	3.26	Very Acceptable
	T2- native Ipil bark	4.04	Acceptable
	T3- Samak Bark	4.15	Very Acceptable
Turbidity	T0 - Control	4.13	Very Acceptable
	T1- Duhat bark	4.14	Very Acceptable
	T2- native Ipil bark	3.69	Very Acceptable
	T3- Samak Bark	4.68	Very Much Acceptable
Consistency	T0 - Control	4.28	Very Acceptable
	T1- Duhat bark	4.25	Very Acceptable
	T2- native Ipil bark	3.29	Very Acceptable
	T3- Samak Bark	4.46	Very Much Acceptable

Figure 1: Sensory Characteristics of Sugarcane Vinegar

As to taste, no addition of tree bark to sugarcane vinegar has the highest mean of 4.05 (very acceptable), while the lowest mean score was obtained in T1 (duhat bark) with a mean of 3.54 and described as "Very Acceptable. "ANOVA results showed significant differences observed between and among the different treatments. Further analysis proved a significant difference between T0 (control) VS T1 to T3. The result indicates that no addition of tree bark to enhance the taste of sugarcane vinegar is most likely by the panel of evaluators. Evaluators opined that sugarcane vinegar had an aftertaste effect on the product when added to tree bark. Although sourness is one of the primary flavors perceived as caused by acidity, it can provide lightness and interest to food that would otherwise be heavy or bland. According to [5], A high-quality sugarcane original vinegar drink was produced from fresh sugarcane juice using the wine yeast and LB acetate bacteria by submerged alcoholic fermentation followed by acetic fermentation at room temperature. The quality parameters of vinegar were investigated during the process of submerged fermentation. It was observed that the alcoholic fermentation period of 9 to 20 days and an acetic fermentation period of 15 to 21 days each in succession, produced the sugarcane quality vinegar with 3.04 % (w/v) total acid and 4° alcoholicity. Besides the vinegar consisted of many saccharides (fructose, glucose, sucrose) and organic acids (oxalic acid, tartaric acid, citric acid, acetic acid). The prominent ingredient of acetic acid ranged from 8.16 to 13.65 mg/g. Vinegar produced by this process yielded a yellow-brown color with full wine aromas and cane flavor, mild and mellow, low alcohol, and

a strong odor of vinegar. The present study provides a new approach to processing sugarcane byproducts, which contributes to the value-added production and processing of sugarcane.

In like manner, the aroma of the sugarcane vinegar is also shown in the table. As reflected in the table, the presence of “Samak" tree bark indicates the highest mean obtained of 4.19 and described as "Very Acceptable," and the lowest mean was seen in T1 (duhat bark) of 3.61; with a descriptive rating of "Very Acceptable." Analysis of Variance test results indicates significant differences between and among treatment means, as shown by different testing results. T0 vs. T1-T3 differs significantly as manifested by the vinegar produced from adding tree bark had a more intense sour taste and aroma than the vinegar produced without tree bark. The addition of tree bark into the sugarcane juice before fermentation helps in the immediate reaction into the mixture thus, this provides the strong aroma of the sugarcane vinegar. This coincides with the study of [3], that the acidity and aroma of the vinegar products using leaves and stems were better than that of the two brands of commercial vinegar.

As to color, it appears on the table that T3 (Samak bark) has the highest mean of 4.15 and is described as "Very Acceptable," while the lowest mean was seen in T1 (Lomboy bark) at 3.26 as "Very Acceptable. “The ANOVA result indicated a significant difference in the color of the vinegar produced when three different tree bark was added during fermentation. Sugarcane vinegar with “Samak” was significantly darker than the vinegar with no tree bark added. However, when native ipil bark and “duhat” bark were compared, no significant differences were observed. From the consumer's perception, the color of the "Samak" was just suitable for vinegar hence more acceptable for them. Similarly, [10] found out that vinegar produced from earthen and stainless containers was significantly darker than the vinegar produced from the glass and plastic containers. Moreover, when tree barks were added during fermentation, giving a darker or brighter color. Cane vinegar are made from sugar cane juice and one of the most popular in the Philippines, particularly in the Ilocos Region of the Northern Philippines where it is called “Sukang Iloko”. It ranges from dark yellow to golden brown in color, and has a mellow flavor, similar in some respects, to rice vinegar, though with a somewhat “fresher” taste, containing no residual sugar, it is not sweeter than other vinegars [2].

Based on the result of the evaluation on turbidity, the use of “Samak” has the highest mean of 4.68 and is described as "Very Much Acceptable," and the lowest mean appeared in T2 of 3.69 as "Very Acceptable ." Further analysis also viewed that all treatments differ significantly. This indicates that the presence of “duhat" bark added during fermentation affects the turbidity of the sugarcane vinegar, as manifested by the presence of tiny fibers that settles at the bottom of the containers. As a result of the study conducted by [9], another reason for vinegar turbidity is also caused by incomplete boiling sterilization. The bacterial strains in the sugarcane juice were still alive. Besides, pasteurization temperatures used for lactic acid bacteria are typically not very high.

In terms of consistency, T3 has the highest mean of 4.46 and is described as "Very Much Acceptable," followed by T0 and T1, and the lowest mean appeared in T2 of 3.29 and was described as "Very Acceptable. "ANOVA result shows that there is a significant difference between treatments. Tukey Kramer's Test result also indicated a significant difference between T2 vs. T3. However, no significant differences were observed between T0 vs.

T1 and T3. As implied, the use of "Samak" still the best acceptable among the evaluators.

3.2 Level of Acidity of the Sugarcane Vinegar

Treatment	1st Sampling	2nd Sampling	3rd Sampling	4th Sampling
T0- Control (No tree bark)	6.0	5.5	4.6	4.0
T1- Duhat tree bark	5.4	5.2	4.2	3.3
T2- (Native Ipil-Ipil tree bark)	5.4	5.1	4.1	3.3
T3- (Samak tree bark)	5.3	4.7	4.0	3.1

Figure 2: The level of acidity of the Sugarcane Vinegar added with different tree barks

From the table, it can be gleaned that the ph (potential of hydrogen) level of the sugarcane vinegar was sampled monthly with four sampling times. As observed during the first sampling, the level of acidity without tree bark has an average mean of 6.0, followed by "duhat" and native ipil tree bark of 5.4 respectively and 5.3 for "Samak" tree bark. Only a slight decrease/increase in the ph (potential of hydrogen) level of the sugarcane vinegar is noticeable in the subsequent sampling period. Results indicate that the addition of tree bark to aid in the fermentation period decreases compared to the regular fermenting practices done by the sugarcane producers in the municipality. The addition of "Samak," according to the sugarcane makers, hastens the fermentation period. With the five months of fermentation storage, the mash already attained an extreme acid level as manifested by the obtained ph level of 3.1.

Treatment	Purchase Intent		General Acceptability	
	Mean	Description	Mean	Description
Treatment 0 (Control- no tree bark)	4.15	Very Acceptable	4.09	Very Acceptable
T1 (Duhat Tree bark)	3.50	Very Acceptable	3.67	Very Acceptable
T2 (Native ipil tree bark)	4.17	Very Acceptable	3.81	Very Acceptable
T3 (Samak tree bark)	4.37	Very Much Acceptable	4.33	Very Much Acceptable

Figure 3: Mean General Acceptability and Purchase Intent Scores of the Sugarcane Vinegar Samples

The result of the consumer testing showed that the different kinds of tree barks in sugarcane vinegar making fall within very acceptable to very much acceptable. The result was shown based on the result that without tree bark, duhat tree bark and native ipil tree bark are "Very Acceptable while the use of Samak tree is very much acceptable. The consumer's acceptability favored sugarcane vinegar produced from "Samak" tree bark and was also evident in the purchase intent measure of the consumer among the vinegar samples presented as manifested by the highest mean given.

3.3 Implications to micro-small enterprises

When the researchers asked the selected sugarcane makers in the municipality about the implications of the study to micro/small enterprises, the following were summarized:

1. Help the local vinegar producer in the Ilocos province to produce consistent quality vinegar, particularly in the Municipality of Sta. Maria (OTOP), with minimal product loss, can maximize their time in the production process.
2. The data generated from this research will serve as the basis for product standardization of sugarcane vinegar.
3. Production of quality vinegar steadily provides an avenue for them to widen their market and increase the demand for more sugarcane as raw materials.
4. Help increase the labor market and widen the area for sugarcane production
5. Uplift the local manufacturers' economic status and boost the province's sugarcane industry.

4. Conclusion

Based on the result of the study, the kind of tree bark plays a significant role in the acidity level of the mash. The rate of fermentation can also be affected by the addition of tree bark, considering that tree bark favors faster alcoholic fermentation. The vinegar produced from using "Samak" tree bark has a more intense sour aroma than the vinegar produced without tree bark. It also has a darker brown color, consistent but comparable appearance, and turbidity. Therefore, the "Samak" tree bark is the best used for vinegar fermentation and coloring agent.

5. Clinical Significance

Vinegar producers should consider the type of tree bark that hasten fermentation and provide brighter color. A natural enhancer and coloring agent are recommended to ensure safety and health benefits to consumers. The addition of tree bark for vinegar production during fermentation enhances sugarcane vinegar's sensory qualities. Further study on the effect of vinegar focusing on food safety, like the microbiological and toxicological evaluation, is highly recommended to fully understand and determine other possible effects on humans in vinegar production.

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