EFFECTS OF THE DIFFERENT TYPES OF CONTAINER ON THE CHARACTERISTICS OF SUGARCANE VINEGAR

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A B S T R A C T

The study was conducted primarily to determine if the type of container used in fermentation affects the physico-chemical and sensory characteristics of sugarcane vinegar produced, its fermentation rate and the product yield. Results of the study revealed that the container type affected the development of the chemical properties of vinegar, its sour and sweet taste, color and the aroma of vinegar produced, its rate of fermentation and the product yield. The best type of containers recommended for use in vinegar production is those which are made up of materials with good barrier properties against light and gases. The study generated data that can serve as reference for local vinegar producer within the province to produce consistent quality vinegar, with minimal product loss and can maximize their production process for the upliftment of their economic status and the sugarcane industry of the province.

Key words: sugarcane, sugarcane juice, vinegar, fermentation, fermentation containers

1. Introduction

In Central Luzon, Tarlac is one of the agricultural provinces, and one of its main agricultural products is sugarcane. This has been a major crop of the province where a lot of farmers are dependent on for their income. Production of cane vinegar provides an avenue for the households of the province to convert their sugarcane and its rejects into income. Little as their productions seems to be, its importance as their means of living has a great role.

Their production exists as backyard business and their neighborhood as their immediate market. Small backyard manufacturers in the province utilize plastic drums and earthen fermenting containers. Their inherent skills in producing vinegar using such containers had been widely acceptable in the community although there are some claims of variations in the quality of color, taste and aroma of their produced. There are also claims; however, that there is no significant difference in terms of these attributes using the two types of fermenting containers. Their measure of quality focused more on the acceptability of their customer, regardless of its consistency. This limits the capability of their products to penetrate its wide potential market.

Analyzing these different claims in the inconsistencies of the characteristics of vinegar, the need for a study to prove or disprove such is really imperative. Previous studies on vinegar production focused more on how to speed up the fermentation process. No comprehensive study on the effects of different types of fermenting containers on vinegar production, specifically on its rate and on the resulting sensory and physico-chemical attributes, has been reported yet. No data yet to support any answer to the question, “Does the type of fermenting containers affects the characteristics of vinegar produced?”

Hence, the purpose of this study is to determine if type of fermenting container used affects the physic-chemical and sensory characteristics of vinegar produced, its rate of fermentation. Physicochemical properties such as pH, total titratable acidity (TTA) and alcohol content as measured by dropped in Total Soluble Solids (TSS) and sensory attributes includes taste, color, and aroma.

2. OBJECTIVES

This study was purposely designed to determine if the type of container used in fermentation affects the characteristics of sugarcane vinegar produced. It specifically aimed to answer the following questions;

1. What is the effect of the glass, plastic, stainless steel and earthen containers on the following characteristics of sugarcane vinegar during and after the fermentation process;
   - 1.1. Development of Physico-Chemical Properties
     - 1.1.1. Percent Total Titratable Acidity (%TTA)
     - 1.1.2. Alcohol
   - 1.2. rate of fermentation
   - 1.3. percent yield
   - 1.4. Sensory Attributes
     - 1.4.1. Taste
     - 1.4.2. Aroma
     - 1.4.3. Color and Turbidity
2. What type of fermenting container is best to recommend for vinegar fermentation?
3. What are the implications of the study to Small and Medium Enterprises (SME) engaged in vinegar production

3. METHODOLOGY

3.1. Research Design

The study utilized the experimental design. This was used in producing sugarcane vinegar using glass, plastic, and stainless steel and earthen as fermenting containers. The results of the sensory evaluation and physico-chemical analyses of the vinegar produced were the basis for the identification of the effects of the different fermenting containers in the characteristics of sugarcane vinegar.

3.2. Research Procedure

A. Materials

Extracted juice from sugarcane was used as the raw material for the vinegar production. Wide mouth containers made of glass, plastic, stainless steel and earthen were used as the fermenting containers. Cheese cloth was used for the filtration of cane juice and as cover for the fermenting jars during acetous fermentation stage. Syringe was used to draw samples from the treatments.

B. Vinegar Production

The experiment used the open vat or surface fermentation method, wherein Acetic acid bacteria was allowed to grow naturally on the surface of the mash. The different types of container containing the cane juice were placed in an open area and allowed the mash to ferment naturally under normal temperature/condition. It simulated the process and condition applied by the backyard manufacturer of sugarcane vinegar in the province.

Stalks of sugarcane were washed and passed through the crusher. Juice was filtered using cheese cloth and collected in plastic containers. Equal volume of filtered cane juice was then placed in the wide mouth containers made of glass, plastic, stainless steel and earthen. These were tightly covered for two months to avoid entry of air during ethanolic fermentation. After which, covers were replaced with cheese cloth until acidity of vinegar reached 4-5 %. When the desired acidity was obtained the vinegar was pasteurized at 60 Degree Celsius for 30 minutes to stop the fermentation process. After pasteurization, the vinegar was cooled down to 21 degree Celsius then packed into clean bottles.

C. Sampling

The experiment used the randomized block design to obtain more reliable results. Thus, for each fermenting container or treatment, there were three trials or replications. Samples for chemical analyses were obtained from each replication and samples for sensory evaluation, on the other hand, were obtained from each treatment.

Samples for chemical analyses were drawn using pre-coded 10mL syringe after 5 days and every other ten days there after of acetous fermentation. On the other hand, samples for sensory evaluation were drawn using pre-coded plastic cups after the pasteurization of the vinegar with 4-5% acidity.

D. Effect of Container Types on the Characteristics of Sugarcane Vinegar

The observations and data gathered from the chemical analyses, and sensory evaluation were analyzed and interpreted and served as a basis for determining the effect of container type on the characteristics of sugarcane vinegar produced. In addition to these data, results of consumer test such as the general acceptability and purchase intent of the potential consumer in the sugarcane vinegar produced were also considered.

E. Chemical Analyses

Chemical analyses were conducted at the Department of Chemistry at the College of Arts and Sciences of Central Luzon State University.

Total Titratable Acidity (TTA) was determined using titration method. Phenolphthalein indicator was added into each 1ml sample vinegar solution. Then it was titrated using the 0.1N NaOH to its pink color end point. Percent total titratable acidity was computed using the formula below:

$$\frac{\text{(ml of NaOH) x (N of NaOH) x (0.06005)}}{\text{Sample Weight}}$$

pH of samples were determined by dipping the pH electrode of the pre-calibrated pH meter in the vinegar samples.

F. Rate of Fermentation

The date wherein the fermentation started and the date wherein the 4-5% acidity of the cane vinegar was achieved were properly noted and tabulated. Rate of fermentation was obtained the counting of the actual number of days of the fermentation process.

G. Percent Yield

The initial volume of sugarcane juice used was recorded as well as the volume of samples for chemical analyses drawn from each container type. After the fermentation process the actual volume of vinegar produced from each container type was measured using graduated cylinder. Then, the percent yield was computed using the following formula;

$$\text{\% yield} = \frac{\text{initial volume – (final volume + total volume of samples) x 100}}{\text{Initial volume}}$$

H. Sensory Evaluation

Vinegar fermented in different types of containers was subjected to Quantitative Descriptive Analysis to determine their specific sensory characteristics. QDA is a technique in which trained individuals will identify and quantify the sensory properties of a product or ingredient in the order of occurrence (de Leon, 2000). Identified attributes of vinegar with significant difference are then subjected to consumer testing using the nine point hedonic scale and the 5 point Just About Right (JAR) scale to determine the consumer acceptability and their perception on the sensory attributes identified, respectively.

I. Instrumentation

Sensory evaluation used the score sheets wherein the evaluations of the panelist were recorded . A form was designed for the recording of the results of the chemical analyses.

J. Statistical Treatment

Analysis of Variance (ANOVA) using Duncan's Range Test was done to determine whether the identified sensory characteristics from the Quantitative Descriptive Analysis (QDA) and the consumer test in the vinegar fermented in different types of containers would differ significantly and this served as the basis for identifying the if the type of container used would affect the characteristics of the vinegar produced.

4. RESULTS and DISCUSSION

Data collected from the study was analyzed and results of which served as the basis for determining the effect of the type of the container on the characteristics of vinegar. Results of data analysis revealed the following;

1. The type of container used in vinegar production has a significant effect in;

1.1 Development of Physico-chemical properties such as % alcohol and %TTA.

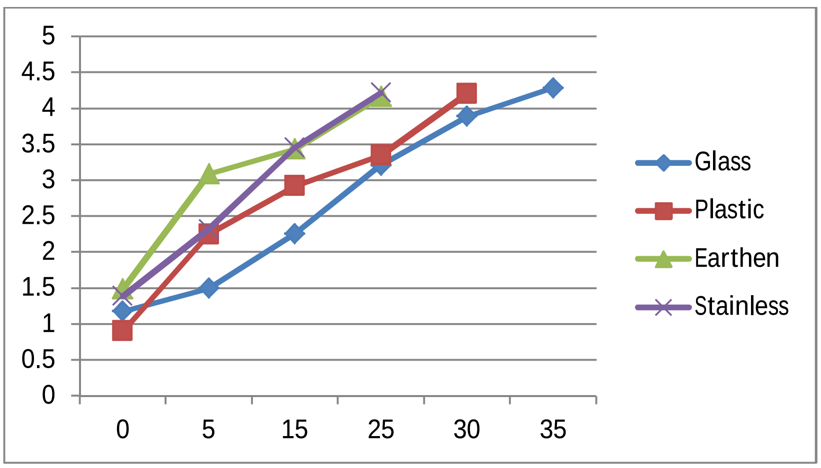

Figure 1. Acetic Acid Development
(x-axis – no of days / y-axis - %TTA)

The more permeable the container material was, like in the case of containers made of plastic and earthen, the faster the development of the acetic acid (figure 1) but the conversion of sugar to alcohol (figure 2) was slower. On the other hand, less permeable container, like the container made of glass and stainless materials, favored the faster conversion of sugar to alcohol and slow development of acetic acid.

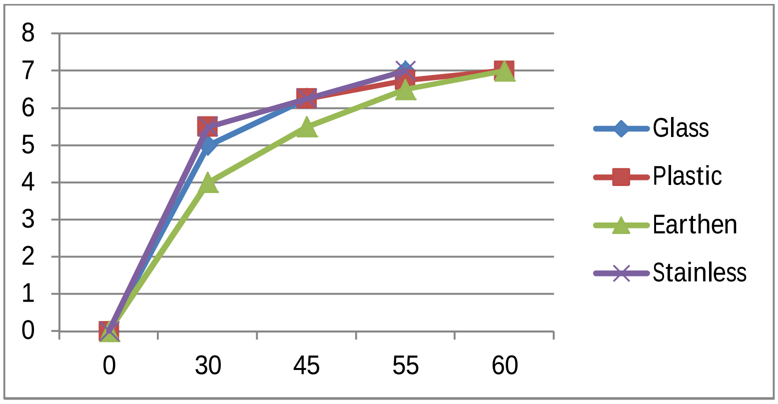

Figure 1. Acetic Acid Development

(x-axis – no of days / y-axis - %Alcohol)

1.2. The rate of fermentation (Table 1.0 below) can also be affected by the type of container used considering the effect that glass and stainless containers favor faster alcoholic fermentation but slower rate of acetous fermentation while the containers made of plastic and earthen materials favor slower rate of alcoholic fermentation but faster rate of acetous fermentation. However, these effects do not significantly affected the length of fermentation process specifically since the same type of container was used from alcoholic to acetous fermentation.

Table1

Rate of Fermentation

Container Type	No of Days		
	Alcoholic	Acetous	Total
Earthen	60	25	85
Glass	55	30	85
Plastic	60	30	90
Stainless	55	25	80

1.3. Glass, plastic and stainless containers had a comparable percent yield (Figure 3 below) which was significantly higher than the yield from earthen containers.

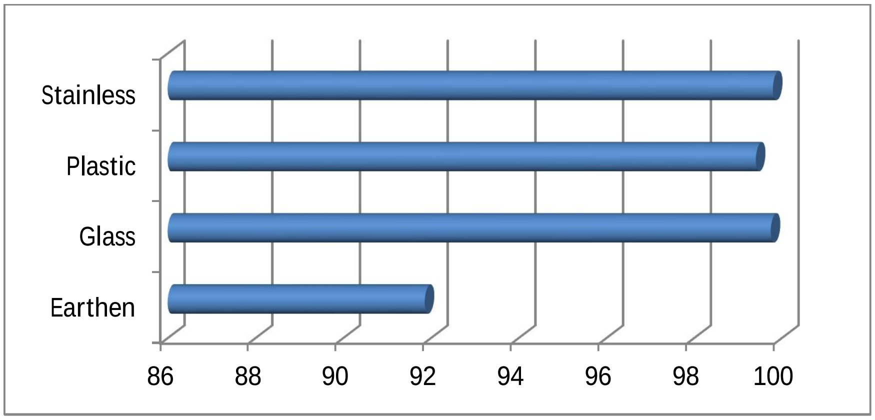

Figure 3. Percent Yield
(X-axis % yield / y-axis –container type)

1.4. Vinegar produced from glass and stainless containers differed significantly in sour taste and aroma than the vinegar produced from plastic and earthen containers (Table 2). The vinegar produced from glass and stainless container had a more intense sour taste and aroma than the vinegar produced in a container made of plastic and earthen materials, despite their comparable % TTA.

Table 2
Taste and Aroma Mean Scores of the Vinegar Samples.

Container Type	Sour Taste	Sour Aroma
Earthen	6.73^{A}	4.83^{A}
Glass	9.50^{B}	6.69^{B}
Plastic	7.47^{A}	4.43^{A}
Stainless	9.31^{B}	5.34^{AB}
Commercial	13.97^{C}	10.18^{C}

* Mean scores followed by the same capital letter superscripts are not significantly different at 5% level based on Duncans range test.

Table 3.0
Color Mean Scores of the Vinegar Samples.

Container Type	Color
Earthen	7.22^{C}
Glass	5.08^{A}
Plastic	5.31^{AB}
Stainless	6.38^{BC}
Commercial	4.22^{A}

* Mean scores followed by the same capital letter superscripts are not significantly different at 5% level based on Duncans range test.

Significant difference on the color (Table 3.0 above)of the vinegar produced from earthen and stainless steel from the vinegar produced in glass and plastic container was also noted. Vinegar produced from earthen and stainless containers were significantly darker than the color of the vinegar produced from the glass and plastic containers.

Table 4.0
Mean Acceptability Scores of the Vinegar Samples.

Container Type	Sourness	Aroma	Color
Earthen	4.60^{A}	4.59^{A}	4.86^{A}
Glass	5.60^{B}	5.46^{A}	5.28^{A}
Plastic	5.04^{AB}	5.12^{A}	5.14^{A}
Stainless	5.20^{AB}	5.14^{A}	4.68^{A}
Commercial	4.50^{A}	5.42^{A}	6.22^{B}

* Mean scores followed by the same capital letter superscripts are not significantly different at 5% level based on Duncans range test.

On the other hand, results of consumer testing (Table 4.0 above)showed that the different effects of container type on the above characteristics of the vinegar produced from the four types of container were equally acceptable for the consumer, except for the color. From the perception of the consumer using the 5-point JAR scale (Table 5 below), the color of the vinegar produced from the four types of container was quite dark for vinegar. The color of the commercially available cane vinegar was just right for vinegar hence more acceptable for them. Taste and aroma on the other hand are equally perceived as just right for vinegar.

Table 5
Mean Scores of Consumer Perception using JAR Scale

Container Type	Sourness	Aroma	Color
Earthen	2.82^{A}	2.82^{A}	3.58^{BC}
Glass	3.58^{AB}	2.60^{A}	3.42^{BC}
Plastic	3.00^{AB}	2.80^{A}	3.28^{B}
Stainless	4.04^{B}	2.47^{A}	3.72^{C}
Commercial	3.38^{AB}	2.70^{A}	2.75^{A}

* Mean scores followed by the same capital letter superscripts are not significantly different at 5% level based on Duncans range test.

Table 6.0
Mean General Acceptability and Purchase Intent
Scores of the Vinegar Samples

Container Type	Purchase Intent	General Acceptability
Earthen	2.94^{A}	4.94^{A}
Glass	3.67^{B}	6.02^{B}
Plastic	3.06^{A}	5.29^{AB}
Stainless	2.86^{A}	5.14^{AB}
Commercial	2.94^{A}	5.20^{AB}

* Mean scores followed by the same capital letter superscripts are not significantly different at 5% level based on Duncans range test.

Overall acceptability of the customer favored the vinegar produced from glass container and this was evident on the purchased intent measure of the customer wherein among the vinegar samples, highest mean score was given to it (Table 6 above).

2. The best type of container for vinegar production should be made of less permeable materials like those made of glass and stainless.

3. The study provided data that can serve as basis for the standardization of sugarcane vinegar. The sensory profile generated from the QDA can help the local vinegar producer within the province to produce consistent quality vinegar, with minimal product loss and can maximize their production process. Producing quality vinegar consistently will provide an avenue for them to widen their market, thus also increasing the demand for more sugarcane as raw material. This, as whole, will contribute in the upliftment of the economic status of the local manufacturers and may boost the sugarcane industry of the province. Moreover, the study generated facts and observations that can be considered in the improvement of the TLE curriculum, specifically in the area of foods. On such specific area, the curriculum may include subjects like, Food Product Development, Product Profiling, Product Quality Assessment and Product Quality Standardization, wherein the students will be given more awareness and be more equipped with knowledge in doing researches in foods. This generally would be of great help in the society considering that food is one of the basic needs of an individual.

5. CONCLUSIONS

With the above results, it is therefore concluded that;

1. The type of container affects the alcohol and acid development of the mash as evident by the % TTA, pH and TSS analyses. The sugar in the mash contained on containers made of less permeable materials like glass and stainless converts faster into alcohol than the sugar in the mash contained in containers made of permeable or porous materials like plastic and earthen. On the other hand, reverse effect is observed during the conversion of alcohol into acetic acid.

2. The rate of fermentation can also be affected by the type of container used considering that the less permeable container materials favors faster alcoholic fermentation but slower rate of acetous fermentation and vise versa. These, however, do not significantly affect the length of fermentation process , considering that same type of container was used from alcoholic to acetous fermentation.

3. Product yield is directly proportional on the permeability of the material of the container type used.

4. The vinegar produced from containers made of glass and stainless has more intense sweet and sour taste and aroma than the vinegar produced from containers made of plastic and earthen. It also has the lightest brown color but comparable turbidity.

5. The best container to be used for vinegar fermentation are those which are made of materials that possess good barrier properties against gases, water , lights and microorganisms and should have a tight structure (not porous) which does not allow easy diffusion. More so, it should have an ideal mouth diameter to minimize loss of volatile components of vinegar which have a direct bearing on its flavor and odor development.

6 . RECOMMENDATIONS

As such, it is recommended that:

1. Vinegar producers should consider the type of container to be used for vinegar production. Containers made of less permeable materials like glass and stainless are recommended to use considering the noted effects of the container type on the above characteristics of the vinegar.

2. Wise choice and evaluation should be done if plastic container is to be used. It should be composed of various polymers with good barrier properties.

3. The vinegar producers must use container which has the ideal mouth diameter and shape, for this can also be factors that affects evaporation of volatile components in vinegar which are important in their flavor and aroma development. The determination of the ideal mouth diameter and shape of the container for vinegar fermentation can be subject for another research, which is also highly recommended.

4. 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 effect of the type of container in the vinegar production.

5. Viability of containers with respect to the quality of vinegar produced should also be studied.

6. Used of containers with similar materials, size and mouth diameter is recommended for the vinegar producers for them to produced vinegar of uniform quality.

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