HANDLING OF COCONUT WATER AND CLARIFICATION OF COCO-VINEGAR FOR SMALL-SCALE PRODUCTION

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ABSTRACT

The study aimed to develop an appropriate small-scale technique of producing sparkling clear vinegar from coconut water. Results indicate that (1) at least 8% w/v alcohol solution is required to produce the standard vinegar with 4% w/v acetic acid by the traditional method, and (2) the alcohol solution can be stored for 6 weeks prior to acetification without affecting the product quality.

In the clarification process, well-beaten egg albumin (preferably 7-9 g egg white/liter vinegar or two egg whites per 10 liters vinegar) was added to raw vinegar. The solution was then stirred and heated to coagulate the albumin. It was allowed to stand for a day, decanted and filtered. The clarified vinegar was aged for 3-4 weeks for further sedimentation before bottling and pasteurization. The samples remained stable even after one year of storage and were accepted in various food preparations.

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KEY WORDS: Vinegar. Coconut water. Handling. Clarification. Egg albumin. Small-scale production.

INTRODUCTION

The Eastern Visayas region of the Philippines has over 345,000 hectares of land planted to coconut with an annual production of about 10 million mature nuts (UCAP, 1983). Almost all of these are processed into copra and many million liters of coconut water are disposed as waste. Thus, a small farmer with one hectare planted to coconut presumably throws away several hundred liters of coconut water per harvest. This waste could provide additional income to the farmers if it is converted into marketable products.

Coconut water contains 4.79% total solids, 2.56% sugars, 0.74%

oil, 0.55% protein and a substantial amount of vitamins, minerals and hormones (Sison, 1984). It can be formulated into beverages or used as substrate for various fermented products such as single cell protein, dextran, nata de coco and alcohol (Banzon and Velasco, 1982). The alcohol obtained from yeast fermentation of sweetened coconut water can further be fermented by acetic bacteria to vinegar. However, coconut water vinegar or coco-vinegar cannot usually compete with commercial ones due to formation of turbid substances and precipitates during storage. The improvement of coco-vinegar quality particularly its clarity, may therefore increase its saleability. This will consequently benefit coco-vinegar producers as well as augment the income of small coconut farmers.

The turbidity of coco-vinegar has not been studied. The formation of cloudy substances may be due to the production of pectic substances, polypeptides, polysaccharides and other substances by microorganisms during fermentation. The "after cloud" formation in cider vinegar was studied but the results were inconclusive (Pers. comm. with Shipley, P.A., U.S. Industrial Chemicals Company, Ohio, U.S.A.)

Commercially, sparkling clear vinegar is obtained by passing the solution through a multi-plate filter at high pressure with diatomaceous earth as the filtering aid (U.S. Industrial Chemicals Company, 1969). For white distilled vinegar, distilled denatured alcohol (SDA 29) is used as substrate for acetic acid fermentation by bacteria (Nickol, 1979). However, both processes seem inappropriate for small-scale operation due to the cost of required equipment in the former and of nutrients added to the fermenter to sustain the growth of bacteria in the latter.

The study was conducted to develop an appropriate method of producing sparkling clear coconut water vinegar which would be affordable to small-scale food processors.

MATERIALS AND METHODS

Coconut water, a by-product of copra making at the Regional Coconut Research Center (RCRC), Visayas State College of Agriculture (ViSCA) was used in the study. The sample was collected in clean containers and brought immediately to the laboratory.

Vinegar Making

The traditional method of making vinegar from coconut water as described by UNIDO-APCC (1979) was adopted with modifications. Brown sugar was added to the coconut water at 16% concentration. The solution was strained through cheese cloth to remove the suspended particles; and the filtrate was boiled for 10 minutes, cooled to room temperature and transferred to a suitable container. Alcohol fermentation was then started by adding 1 g Bakers' yeast to every liter of coconut water. The container was covered with clean cheese cloth and fermentation was allowed to take place for 5-7 days. The alcohol solution was siphoned out and poured into a wide-mouth fermentation vat. Mother vinegar was added to the alcohol solution and the mixture was incubated for 3-4 weeks for acetification. The raw vinegar was then used in the clarification study.

Effects of Alcohol Content and Storage of Alcohol Solution on Acetic Acid Content of Coco-Vinegar

To determine the effect of alcohol content on quality of vinegar, the alcohol solution resulting from yeast fermentation of coconut water was diluted with water to obtain 4, 6 and 8% concentrations. The solutions were then transferred to jars with two replications per treatment for acetic acid fermentation.

The effect of storage of alcohol solution prior to acetification on vinegar quality was determined by storing the alcohol solution at ambient conditions for 0, 2, 3, 4 and 6 weeks. Aliquots were obtained weekly for acetification. Acetic acid content in the fermenting samples was determined and vinegar samples were clarified and subsequently subjected to sensory evaluation.

Clarification of Vinegar

Coco-vinegar was clarified using celite, activated carbon and albumin as clarifying agents.

Celite. Vinegar solution was filtered through filter paper covered with 1-cm thick celite. In another treatment, 1% w/v celite as a filtering aid was added to the vinegar and the mixture was poured through filter paper coated with 1 cm celite.

Activated Carbon. Filter paper covered with 1-cm thick activated carbon was used to clarify the vinegar. In another treatment, 1% w/v activated carbon was added to the vinegar solution before the mixture was poured through a 1-cm thick activated carbon-coated filter paper.

Albumin. Well-beaten egg white was added to raw vinegar at concentrations of 5, 7 and 9 g/L. The solutions were stirred and heated until the albumin coagulated. These were allowed to stand for a day, then decanted and filtered through cheese cloth covered with cotton or coarse filter paper. The clear vinegar was aged for 3-4 weeks for further sedimentation before bottling and pasteurizing at 60-70°C for 20 minutes.

Analyses

Aliquots of raw vinegar were centrifuged and cloudy substances were collected for standard proximate analysis (AOAC, 1975). Alcohol and acetic acid content were determined following the methods described by Adams (1980). The clarity of vinegar was monitored using a Hellige turbidimeter (Hellige Inc., New York, U.S.A.).

Sensory Evaluation

Traditional dishes (pickles, pork adobo) which use vinegar as an important ingredient were prepared using either the clarified coco-vinegar, coconut sap vinegar or a high-quality commercial vinegar. The products were subjected to sensory evaluation by an 8-man taste panel using the Hedonic scale. Samples were served following the completely randomized design (CRD).

RESULTS

Chemical Changes during Fermentation of Coconut Water Vinegar

Changes in pH, alcohol and acetic acid content during natural fermentation of the sweetened coconut water for vinegar production are shown in Figure 1. The pH of the fermenting solution decreased gradually with time. The alcohol content increased rapidly during the first few days of yeast fermentation and reached a concentration of about 10% after 7 days. It subsequently decreased after the mother vinegar was added to start the acetification process. Two weeks later, acetic acid concentration of the solution reached 4.0% w/v, the legal standard acetic acid content of vinegar (Vaughn, 1954). Afterwards, the rate of acetic acid formation declined and vinegar with 5.6% w/v acetic acid was obtained after 5 weeks.

Effects of Alcohol Content and Storage of Alcohol Solution on Acetic Acid Content of Coco-Vinegar

The acetic acid content of coco-vinegar as affected by alcohol concentration is presented in Table 1. During the first week of acetification, acetic acid content was not significantly influenced by alcohol concentration. However as fermentation continued, the different treatments significantly differed in acetic acid content. Only 8% alcohol or higher could produce the standard vinegar with 4% acetic acid.

Table 2 shows the changes in alcohol solution during storage and the acetic acid content of coco-vinegar as influenced by storage of alcohol solution prior to acetification. Alcohol content of the solution increased on the second week but remained relatively unchanged on the third week of storage and then started to decline. Acetic acid formation during storage of the alcohol solution prior to acetification was negligible. During acetification, vinegar with more than 4% w/v acetic acid was obtained in all treatments after 2 to 3 weeks of fermentation. There was no significant difference in acetic acid content of the samples.

Chemical Composition of Cloudy Substances in Coco-Vinegar

The cloudy substances in the coco-vinegar under study contained

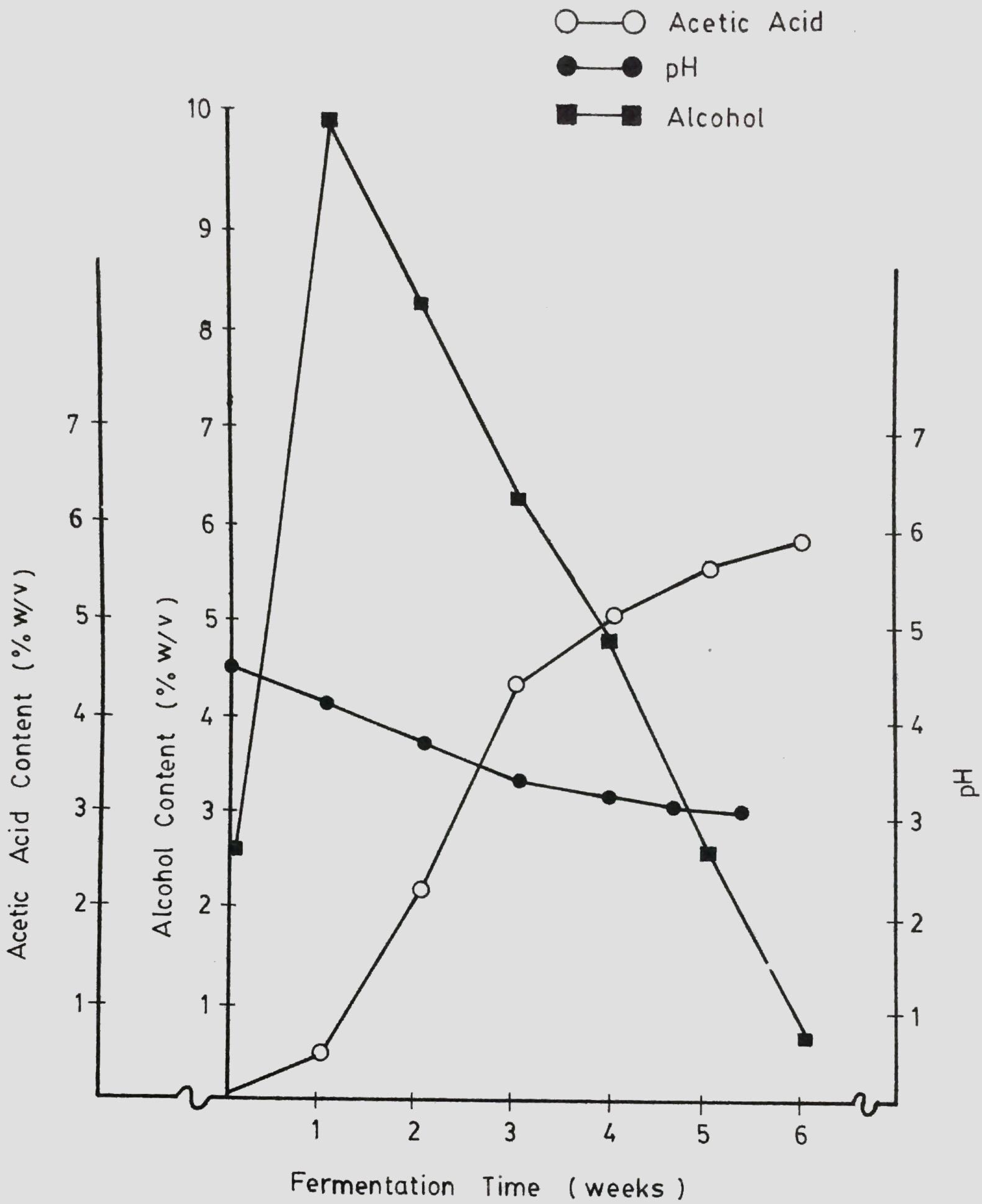

Figure 1. Changes in alcohol, pH and acetic acid content during yeast fermentation and acetification of sweetened coconut water.

Table 1. Effect of alcohol concentration on the acetic acid content of coco-vinegar.

Alcohol Concentration (% w/v)	Acetic Acid Content (% w/v)[1] Fermentation Time (weeks)			
	1	2	3	4
4	2.06a	2.84a	2.63a	2.57a
6	2.55a	3.71b	3.76b	3.37b
8	2.47a	4.15c	4.31c	4.00c
10	2.11a	4.12c	5.00d	5.17d

[1] In a column, means with the same letter are not significantly different at 5% level, DMRT.

Table 2. Changes in the alcohol solution during storage and acetic acid content of coco-vinegar as affected by storage of alcohol solution prior to acetification.

Storage Time (weeks)	Changes in Alcohol Solution During Storage			Acetic Acid Content of Coco-Vinegar (% w/v) Acetification Time (wks)			
	pH	% alcohol	% acetic acid	1	2	3	4
0[1]	3.6	9.78	0.44	2.80	4.43	5.70	5.97
2	3.8	11.60	0.46	2.96	4.43	4.90	6.31
3	3.8	11.50	0.40	2.96	3.95	5.80	6.50
4	3.8	10.60	0.45	2.67	4.20	4.40	6.50
6	3.8	10.08	0.45	2.50	4.87	4.89	5.20

[1] Acetification started after 7 days of yeast fermentation of coconut water.

18% protein, 11.9% starch, 1.5% crude fiber, and 11.2% ash (dry weight basis).

Clarification of Coco-Vinegar

The turbidity readings of coco-vinegar after treatment with various clarifying agents are presented in Table 3. All treatments reduced the turbidity of the vinegar compared to the untreated raw sample. Passing the latter through a filter paper coated with 1-cm thick celite produced vinegar with a turbidity reading of 19.9 ppm SiO_2. Vinegar with the same clarity can also be obtained by adding 1% w/v activated carbon to the vinegar before filtering it through carbon-coated filter paper. The samples prepared following these treatments had higher turbidity readings than commercial clear vinegar.

Egg albumin was the most effective agent in clarifying coco-vinegar. The samples treated with 7-9 g egg white per liter vinegar or roughly two egg whites per 10 liters of vinegar were very close to a commercial clear vinegar in clarity (Table 3). The latter is one of the best quality and most expensive vinegar in the market.

Table 3. Turbidity readings of coco-vinegar treated with various clarifying agents.

Treatment	Turbidity Reading[1] (ppm SiO_2)
Raw vinegar	79.7
Clarified with celite	
T_1 — Filter paper coated with celite at 1 cm thickness	19.9
T_2 — As T_1 + 1% w/v celite added to the vinegar as filtering aid	21.1
Clarified with activated carbon	
T_3 — Filter paper coated with 1-cm thick activated carbon	45.8
T_4 — As in T_3 + 1% w/v activated carbon added to the vinegar as filtering aid	20.3
Clarified with egg albumin	
T_5 — Addition of egg albumin at 5 g/L	11.2
T_6 — Addition of egg albumin at 7 g/L	8.5
T_7 — Addition of egg albumin at 9 g/L	6.7
Commercial clear vinegar	
Brand A	14.5
Brand B	7.7

[1]The smaller the value, the clearer is the solution.

Stability of the Clarified Vinegar During Storage

The clarified coco-vinegar produced some precipitates during storage when it was bottled immediately after clarification. However, aging the clarified vinegar for a few weeks before bottling prevented formation of precipitates during storage. Aged clarified vinegar stored for a year showed no changes in acetic acid concentration (Table 4).

Table 4. Stability of clarified vinegar during storage.

Storage Time (months)	Acetic Acid Content (% w/v)
6	4.97
9	4.97
12	4.93

Sensory Qualities of the Clarified Coco-Vinegar

The sensory qualities of the clarified coconut water vinegar, coconut sap vinegar and a commercial vinegar are compared in Table 5. The acceptability of the tested vinegars in the preparation of pickles and pork adobo was not significantly different.

DISCUSSION

Theoretically, 0.51 g ethyl alcohol would produce 0.67 g acetic acid, or a 3% alcohol solution would be enough to produce the standard vinegar with 4% acetic acid. In practice, Adams (1980) and Nickol (1979) found that 4% alcohol solution was needed to make vinegar containing 4% acetic acid. However following the procedure described in this study, at least 8% alcohol in the yeast fermented solution is required to produce the standard vinegar. This implies low efficiency of the acetification steps in the traditional method of coco-vinegar making.

The rate of acetification as monitored in this study was very low. It took 2 weeks before the acetic acid concentration reached 4% w/v in the traditional method while a period of 3-5 days was sufficient for fermentation of coco-vinegar using a bamboo generator as reported by Santos et al. (1973).

Several factors are known to affect the acetification rate. These are bacterial strains, temperature and ratio of surface area to volume of the liquid and aeration (Adams, 1980). The same author also noted that an increase in the surface area to volume ratio accelerates the acetification rate in a static fermenter.

The alcohol solution obtained from yeast fermentation of the sweetened coconut water could be stored for 1-6 weeks without change. As shown in Table 2, aliquots taken from the stored alcohol solution produced equally good quality vinegar like the control wherein acetification started at 7 days after yeast fermentation. These findings imply

Table 5. Mean sensory evaluation scores of pickles and pork adobo prepared with different kinds of vinegar.[1]

Kind of Vinegar	Pickles					Pork Adobo		
	Aroma	Appearance	Texture	Sourness	General Acceptability	Aroma	Sourness	General Acceptability
Clarified coconut water vinegar	7.33	7.86	7.66	7.53	7.60	7.72	7.64	7.61
Coconut sap vinegar	7.00	7.66	7.53	7.26	7.36	7.36	7.57	7.54
Commercial clear vinegar	7.40	7.60	7.80	7.53	7.70	7.50	7.43	7.50

[1] 9 - Like extremely, 8 - like very much, 7 - like moderately, 6 - like slightly, 5 - neither like nor dislike, 4 - dislike slightly, 3 - dislike moderately, 2 - dislike very much, and 1 - dislike extremely.

that the problem of collecting coconut water in remote areas where copra-making sites are widely scattered, can possibly be solved. Coconut water is rich in nutrients and is thus a good medium for microbial growth. The liquid spoils easily within hours under ambient conditions. Alcohol fermentation should therefore be made right at the copra-making sites either by coconut farmers or by coco-vinegar processors who may contract the former. In this way, the fermented coconut water could be safely transported to the vinegar factory within several weeks. Depending on the operational capacity of the factory, suitable types and sizes of vinegar fermenters could be selected accordingly.

In such a centralized scheme of coco-vinegar processing, the fermentation parameters affecting the yield and quality of the product can be monitored. Moreover, clarification of the vinegar can be integrated as an additional processing step to improve its market value. The findings in this study show that a combination of egg albumin treatment and subsequent aging of the vinegar for several weeks was most effective in producing sparkling clear coco-vinegar with good quality. It is postulated that the interaction of albumin with cloudy substances in the vinegar followed by coagulation of the albumin upon heating, resulted in the clarification of coco-vinegar. Yamasaki et al. (1967 as cited by Neubeck, 1975) reported that the interaction of a positive colloid such as gelatin at pH 3.5 with the negatively-charged cloudy substances, the hydrolyzed pectin in the pectic enzyme-treated fruit juice, enhanced the clarification of the juice.

At a concentration of 7-9 g egg albumin per liter of vinegar or roughly two egg whites per 10 liters of vinegar, the cost of raw material needed for vinegar clarification is about ₱0.35 per liter of the sparkling clear product. The computation is based on the 1985 price of ₱1.60 per egg. Considering the market value of sparkling clear vinegar which is about 2-3 times higher than that of the turbid one, the clarification technique appears to be economically feasible. Individual farmers as well as small-scale vinegar processors can adopt the technology without considerable difficulties because of the simplicity of the technique and the availability of the needed materials in villages.

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