DEVELOPMENT OF SWEETPOTATO-BASED FERMENTED BEVERAGE

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ABSTRACT

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The optimum time for fermentation and suitable fermenting container was established for the production of sweetpotato-based fermented beverage. Evaluation of the beverage was done through physicochemical and sensory analyses by trained panelists. The acceptability score in terms of flavor and general acceptability of 8-day fermented beverage was the same as the beverage produced in 12 and 16 days. The beverage that was fermented in glass jars had a fair to good blend of sweet, sour and alcohol taste compared with the beverages fermented in clay and plastic jars.

There were comparable amounts of sweetness in flavored and unflavored fermented beverages. In general, the acceptability scores for flavored and unflavored beverages in terms of alcohol amount, sourness, sweetness, flavor and general acceptability were the same. The use of either natural fruit or artificial fruit flavorings or both did not cause any significant differences in the quantification of tastes and their corresponding acceptability scores.

Orange-flavored and pineapple-flavored were the most expensive and cheapest fermented beverage, respectively. Unflavored beverage was the cheapest of all the fermented beverages produced.

KEY WORDS: *Aspergillus awamori. Aspergillus kawachii.* Microbial starter. Physicochemical characteristics. Sensory characteristics. Sweetpotato-based fermented beverage.

INTRODUCTION

The production of fermented beverage is basically an alcoholic fermentation process brought about by the action of microorganisms. The

most common type of fermented beverage is wine which is the end product of complete or partial alcoholic fermentation of fresh grapes. Grapes contain sugars and nitrogen compounds which are the principal substrates for alcoholic fermentation. Sugars, especially the simple or fermentable ones like glucose, fructose and mannose, are degraded directly into alcohol although most yeasts have a certain degree of preference for glucose (Benda, 1982). Alcohol is produced from sugary or starchy materials. Sweetpotato, being a starchy material, is a potential substrate for fermented beverage. It contains about 20.10% starch (Bradbury, 1988). Starch is hydrolyzed into fermentable sugar prior to alcoholic fermentation. Hydrolysis of starch can be done using acid through chemical process or enzyme action from microbial fermentation. Unlike acid, microbial enzymes can be produced at a rapid rate with relatively low cost due to the simple method of cultivation of the organisms and enzyme purification (Joson, 1978).

Various types of fermented beverages from different substrates are now available in the market. These beverages contain relatively high amount of alcohol which is hazardous to human health. Wine, being the most common type of fermented beverage contains as high as 20% alcohol by volume while beer, a malted and hopped alcoholic beverage, has 4% alcohol.

One of the major causes of accidents and several disorders or diseases in the human body is the high amount of alcohol intake. The US Department of Health and Human Services (1988) reported that in 1983, about 42% of the total deaths from all motor vehicle accidents were due to alcohol. In 1980, nearly 20,000 deaths were estimated to be caused by alcohol use, alcohol liver disease, alcoholism, alcohol psychosis, alcohol cardiomyopathy, alcohol gastritis, alcohol polyneuropathy, non-dependent use of alcohol and accidental alcohol poisoning. Furthermore, about 1,400 to 2,000 babies born each year had birth defects due to alcohol intake by mothers during pregnancy. Moreover, excessive alcohol intake increases the risk of malnutrition through

a variety of pathophysiologic mechanisms including direct and indirect alterations in both nutrient intake and requirements, digestion, absorption, transport, storage, metabolism and excretion.

In some societies, however, indigenous foods that contain alcohol as a result of fermentation are consumed for protection against the development of deficiencies in vitamins, amino acids and other essential nutrients (Steinkraus, 1979; Darby, 1979). Dirar (1993) reported that the traditional fermented beverage ("hulu-mur") from Sudan contains not only alcohol but also about 31% absorbable sugars which can replenish glucose in the blood. Realizing the importance of food fermentation, he recommended the improvement of the existing technology of rural people by strengthening the role of fermented foods and beverages in the struggle against malnutrition, seasonal food shortage and famine. In this study, therefore, an attempt was made to produce a sweetpotato-based fermented beverage with a very minimal amount of alcohol, which may partially substitute some of the available fermented beverages in the market, especially wine.

MATERIALS AND METHODS

Screening of panelists for sensory evaluation of fermented beverage

A total of 41 judges (staff from PRCRTC and other ViSCA departments) who were consistently involved in the sensory evaluation of developed root crop food products were screened. Screening was done by serving solutions of sugar, acid and alcohol at different concentrations. The concentrations of the solutions were within the range of concentrations in the actual fermented sweetpotato beverage. These concentrations were as follows:

Acid (lactic acid): 0.4, 0.8 and 1.2%
Sugar: 2°, 4° and 6° Brix
Alcohol: 2.0, 4.0 and 6.0%

The panelists were asked to taste and arrange the sample served to them in increasing or decreasing concentrations, and identify the basic tastes that were present in the sample. The samples were served twice with two replications per serving.

Preparation of materials for fermentation

Microbial starter

Cultures of *Saccharomyces cerevisiae* were transferred in MYA slants and incubated for 3-4 days. The slant culture was transferred in YM broth and incubated for another 3-4 days.

A culture of *Aspergillus awamori* was transferred in PDA slants and incubated for 2 days. The slant culture was transferred to sterilized rice in an Erlenmeyer flask and incubated for another 3 days. The culture was then transferred to steamed rice in a tray, covered with clean cheesecloth and incubated for 2 to 3 days.

The yeast starter in the YM broth and the mold starter in the tray were mixed and incubated for another 3-5 days. This mixed culture served as starter for alcohol fermentation.

Sweetpotato

Healthy sweetpotato (Red Wonder) roots were used in the study. The roots were washed, peeled and cut into cubes (approximately 1 in^3 = 16.39 cm^3), steamed for 1 h, and cooled. After cooling, equal amounts of water (1:1; w/v, sweetpotato:water) was added and blended in a Waring Blender.

Fruits

Fruits that were in season such as apple, chico, jackfruit, mango, orange and pineapple were used as natural flavorings in fermented sweetpotato beverage. These fruits were blanched for 1 min prior to fermentation to kill surface yeasts that are undesirable in the fermentation process. Forty percent (by weight of sweetpotato) of

each fruit was incorporated in sweetpotato for the production of fermented beverage.

Determination of optimum time for fermentation

Using *A. awamori* and *S. cerevisiae*, fermentation of sweetpotato-based fermented beverage was done for 16 days using narrow-mouthed glass jars with a capacity of 3.8 L. The physicochemical characteristics were monitored at 0, 4, 8, 12 and 16 days of fermentation. Sensory evaluation was done to determine consumers' perception on the intensity of sweetness, sourness and alcohol content of the product and the blends of three taste components, as well as acceptability in terms of flavor and general acceptability.

Selection of suitable container for fermentation

In addition to glass, other types of low-cost containers such as clay and plastic jars were tried in the fermentation of sweetpotato beverage. Fermentation was done using the optimum fermentation time. After fermentation, the fermented beverages were harvested, pasteurized and bottled. Sensory evaluation was likewise conducted to determine the most suitable fermentation container for producing the most acceptable beverage. The intensity of sweetness, sourness and amount of alcohol as well as the blend of these three tastes and the acceptability scores in terms of these tastes were evaluated.

Physicochemical analyses of fermented sweetpotato beverage

The fermented beverage was analysed for its total titratable acidity (TTA), total soluble solids (TSS) and pH. The TTA was analyzed using the titration method with standardized NaOH solution. The TSS and pH values were simply read from a refractometer (0-30 Brix) and pH meter, respectively.

Production of fruit-flavored fermented beverage

Fruits that were in season were prepared as described (Preparation of materials for fermentation) and fermented with sweetpotato for 8 days. Fermented non-flavored beverage (sweetpotato only) served as control. After fermentation, the fermented beverages were harvested and pasteurized. After clarification for 1 mo, sensory evaluation was done to determine consumers' preference for the different flavors.

The effect of artificial mango flavor (0.10%) in fermented beverage was also determined. The treatments used were as follows:

a) pure sweetpotato-based fermented beverage + 0.10% artificial mango flavor
b) naturally fermented mango and sweetpotato-based beverage
c) naturally fermented mango and sweetpotato-based beverage + 0.10% artificial mango flavor

Production cost of fermented sweetpotato-based beverage production

The cost of producing fermented sweetpotato-based beverage with different fruit flavorings such as apple, chico, jackfruit, mango, orange and pineapple was determined.

RESULTS AND DISCUSSION

Screening of panelists for the sensory evaluation of fermented beverage

Out of 41 panelists who were screened for the sensory evaluation of fermented beverage, only 22 judges passed. These judges were selected on the basis of their ability to identify the solutions of acid, alcohol and sugar and arrange them in increasing or decreasing

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Out of 41 panelists who were screened for the sensory evaluation of fermented beverage, only 22 judges passed. These judges were selected on the basis of their ability to identify the solutions of acid, alcohol and sugar and arrange them in increasing or decreasing

concentrations. The panelists who passed the screening process were used as regular panelists in the development of fermented sweetpotato beverage.

Production of fermented beverages

Determination of optimum time for fermentation

The 8-day fermented beverage had low amount of TTA and pH with relatively high amount of TSS with moderate amount of alcohol content (Table 1). High amounts of acid and alcohol were found to be at 4 and 12 days of fermentation, respectively.

The acceptability of beverage at 4, 8, 12 and 16 days of fermentation was determined and compared with one another (Table 2). Sweetness was more detectable at 8 days, the level of which was comparable with 4 and 16 days of fermentation. Beverages from 8, 12 and 16 days of fermentation had comparable acceptability scores in terms of flavor and general acceptability. Since 8-day fermented beverage was equally acceptable as 12 and 16 days, succeeding beverage production was based on 8-day fermentation. Prolonging the fermentation time up to 16 days may seem impractical since 8-day fermented beverage would have the same acceptability scores as 12 and 16 days in terms of flavor and general acceptability. Furthermore,

Table 1. Mean scores for physicochemical constituents of beverage fermented in a glass jar with different days of fermentation.[1]

Chemical constituents	Fermentation time, days				
	0	4	8	12	16
pH	4.58a	4.02b	3.70c	3.92b	3.47d
Total soluble solids (TSS)	0.28c	0.36c	0.70b	0.52bc	1.16a
Total titratable acids (TTA)	6.50a	3.45b	3.70c	3.80bc	4.00b
Alcohol (%)	0.00c	3.75b	4.75b	6.45a	3.75b

[1] Mean scores in a row with common letters are not significantly different at 5% level according to Duncan's Multiple Range Test (DMRT).

Table 2. Mean sensory attributes and general acceptability of beverage using glass jars at different times of fermentation.[1]

Sensory attributes	Fermentation time, days			
	4	8	12	16
Sweetness[2]	1.46ab	1.83a	1.42b	1.71ab
Sourness[2]	1.58d	2.79b	2.20c	3.50a
Alcohol[2]	2.67a	2.80a	2.66a	2.62a
Blend of taste[3]	1.50c	2.70ab	2.20b	3.10a
Flavor[4]	3.42b	4.50a	4.84a	4.54a
General acceptability[4]	3.50b	4.46a	4.75a	4.58a

[1]Mean scores in a row with common letters are not significantly different at 5% level according to DMRT.
[2]Rating scale: (1) none to (4) strong
[3]Rating scale: (1) poor blend of sweet, sour and alcohol taste to (5) excellent blend of sweet, sour and alcohol taste
[4]Rating scale: (1) dislike extremely to (9) like extremely

a good blend of sweet, sour and alcohol taste was detected in both 8- and 16-day fermented beverage.

Determination of suitable containers for fermentation of sweetpotato beverage

The alcohol contents of beverages from three types of containers however, were found comparable with one another (Table 3). The

Table 3. Mean scores for the physicochemical constituents of fermented beverage using different types of fermentation containers.[1]

Chemical constituents	Types of containers		
	Glass	Plastic	Clay
pH	3.98a	3.98a	3.67b
Total soluble solids (TSS)	4.21a	4.01b	4.29a
Total titratable acids (TTA)	0.52b	0.50b	1.00a
Alcohol, %	3.17a	3.20a	3.03a

[1] Mean scores in a column with common letters are not significantly different at 5% level according to DMRT.

use of clay jars for the fermentation of sweetpotato beverage produced high amount of acid as reflected in high TTA and low pH values. Both glass and clay jars produced beverages with high TSS values. The use of glass and clay jars seemed to favor the activity of microbial starters that hydrolyze carbohydrates with high molecular weight into simple or soluble sugars.

The major acids in wine are tartaric and malic acids although other acids are usually present in varying concentrations (Beelman and Gallander, 1979). A poor correlation between pH and total acidity in wine was reported by Wejnar (1968). The increase in the concentration of tartaric acid caused an increase in pH while a decrease in pH was observed as the concentration of malic acid was increased. It seemed, therefore, that the predominant acid in sweetpotato beverage was malic acid since a negative correlation existed between pH and TTA. The determination of the type of acid present in the fermented beverage is important in providing tartness to the product. Tartness is the pleasing fresh taste of wine. This is influenced by the acids, sugar and other components in wine.

Evaluation of the intensities of basic taste of the beverage revealed that sweetness is equally weak in all beverages fermented in all types of containers (Table 4). The high level of acid in clay-fermented beverage was detected to be of moderate amount similar to plastic fermented beverage. The beverages fermented in glass and plastic containers possessed a low degree of sourness. The level of alcohol was found to be of higher intensity when fermented in glass and plastic than in clay. Likewise, beverage fermented in glass was found to have nearly good blend of sweet, sour and alcohol taste like the beverage produced in plastic container. Beverage fermented in clay had nearly fair blend of basic taste. The difference in the intensity of sweet, sour and alcohol taste however did not affect their corresponding acceptability scores. The acceptability of the beverages in terms of sweetness, sourness, alcohol and even the blends of this

Table 4. Mean sensory scores for the intensity and the corresponding acceptability of the fermented beverage in different fermentation containers at 8-day fermentation.[1]

Sensory qualities	Types of containers		
	Glass	Plastics	Clay
Sweetness[2]	2.04a	2.04a	2.04a
(Acceptability)	(5.33a)	(4.79a)	(4.29a)
Sourness[2]	2.67b	2.96ab	3.17a
(Acceptability)	(5.50a)	(5.50a)	(4.54a)
Alcohol,%	3.13a	2.79ab	2.42b
(Acceptability)	(5.38a)	(5.46a)	(4.75a)
Blend of taste[3]	2.42a	2.25ab	1.79b
Flavor[4]	5.75a	5.58a	5.04a
General acceptability[4]	5.33a	5.33a	4.58a

[1] Mean scores in a row followed by common letters are not significantly different at 5% level according to DMRT.
[2]Rating scale: (1) none to (4) strong
[3]Rating scale: (1) poor blend of sweet, sour and alcohol taste to (5) excellent blend of sweet, sour and alcohol taste
[4]Rating scale: (1) dislike extremely to (9) like extremely

basic tastes are the same. Low amount of acid was produced in beverage fermented in glass jars. This amount of acid produced a relatively good blend of sweet, sour and alcohol taste. In German wines, a harmonizing influence of residual sugar with the acidity of these wines was observed by Munz (1965). It is possible that the reduced amount of acidity in glass-fermented beverage matched the amount of unfermented sugar, thereby producing a better mix of taste in wine. Furthermore, the high amount of TSS in glass-fermented beverage might have reduced its apparent acid taste. Amerine (1964) found that the concentrations of acids were more distinguishable at lower sugar concentrations while alcohol moderated the acidic taste of wine. The relatively high alcohol as detected by the panelists might have influenced their low detection for acid taste.

Clay containers seemed to favor the growth and activity of acid-producing microorganisms but inhibit the activity of pure culture starters which were responsible for the production of alcohol. This may be due to the cooling effect which inhibits the growth and activity of fermenting microorganisms. This cooling effect is similar to the method used in crop storage where heat generated by the commodity is used to evaporate the water inside the clay jar, thus making the immediate environment cool and moist (Bautista, 1990). In fermentation of beverage, heat is also generated from the process which could evaporate the water and lower the temperature inside the jar. The concentration of acids was also reported to increase at lower temperature (about 25°C) while alcohol content decreases at temperatures approaching 15°C although the formation of higher alcohols is favored at a temperature of about 20°C (Benda, 1982).

Production of fruit-flavored sweetpotato beverage

Table 5 presents the intensities of alcohol taste, sourness and sweetness of fruit-flavored fermented sweetpotato beverages as detected by the panelists. The alcohol content was found to be moderate

Table 5. Mean scores for the intensity of sensory qualities of fruit-flavored and non-flavored sweetpotato fermented beverage.[1]

	Sensory Qualities[2]		
Treatment	Alcohol	Sourness	Sweetness
Apple + SP	3.42a	3.67a	2.33a
Chico + SP	2.33c	2.75bc	2.58a
Jackfruit + SP	2.75bc	2.75bc	2.83a
Mango + SP	3.17ab	2.25c	2.83a
Orange + SP	3.08ab	2.83bc	2.25a
Pineapple + SP	3.00ab	2.75bc	2.67a
Plain SP (Control)	2.92ab	3.25ab	2.50a

[1] Mean scores in a row followed by common letters are not significantly different at 5% level according to DMRT.

[2] Rating scale: (1) none to (4) strong

when apple, mango orange and pineapple were used as natural fruit flavorings; alcohol intensity was similar to that of the non-flavored fermented sweetpotato beverage. Chico and jackfruit produced weak to moderate amounts of alcohol based on sensory evaluation. Apple-flavored and plain sweetpotato beverages were evaluated to have high amount of acid. Other fruit flavorings such as chico, jackfruit, mango, orange and pineapple seemed to produce weak to moderate levels of sourness in beverage. Sweetness in all beverages was the same, being weak to moderate as detected by the panelists.

Almost all the panelists commented that the natural flavorings that were incorporated in the sweetpotato during fermentation did not contribute much flavor to the fermented beverage. These flavorings therefore were hardly detected during sensory evaluation. Because of this, all beverages produced with and without fruit flavorings, except for apple, had the same acceptability scores in terms of alcohol taste, sourness, sweetness flavor and general acceptability (Table 6).

In an attempt to improve the taste of the beverage, artificial flavoring was added to the fermented beverage. Results showed that in general,

Table 6. Mean sensory scores for the acceptability of fruit-flavored and non-flavored fermented sweetpotato beverage.[1]

Treatment	Acceptability Scores[2]				
	Alcohol	Sourness	Sweetness	Flavor	General Acceptability
Apple + SP	6.17a	5.17b	6.17a	5.42a	5.50a
Chico + SP	5.83a	5.75ab	6.08a	6.17a	5.96a
Jackfruit + SP	6.00a	5.83ab	6.25a	6.50a	6.21a
Mango + SP	5.83a	5.88ab	6.00a	5.96a	6.00a
Orange + SP	5.83a	5.88ab	5.56a	5.42a	5.33a
Pineapple + SP	6.00a	6.42a	6.00a	6.50a	6.25a
Plain SP(Control)	6.00a	6.42a	6.50a	6.17a	6.38a

[1] Mean scores in a row followed by common letters are not significantly different at 5% level according to DMRT.

[2] Rating scale: (1) dislike extremely to (9) like extremely

still no differences were observed in the assessment of sensory characteristics and in their acceptability scores during evaluation (Table 7). However, the panelists gave a general comment that the artificially flavored beverage had a pleasing aroma although this was not clearly reflected in their responses; no significant differences were observed in their acceptability scores although higher acceptability scores for flavor was noted in beverages with artificial flavor.

Production cost of fermented flavored and non-flavored sweetpotato beverage

The orange-flavored beverage was found to be the most expensive beverage with a total production cost of₱518.58 in a batch process that

Table 7. Mean sensory scores for fermented sweetpotato beverage with 0.10% artificial mango flavor.[1]

Sensory parameters	Naturally fermented sweetpotato + mango flavoring	Naturally fermented sweetpotato + artificial flavoring	Naturally fermented sweetpotato + mango+artificial flavoring
Sweetness[1]	2.79 a	2.96 a	2.62 a
Sourness[1]	3.21a	2.42b	3.38a
Alcohol[2]	2.92a	2.75a	3.17a
Blend of taste[3]	1 79a	2.12a	2.12a
Acceptability scores[4]			
Sweetness	6.25a	6.50a	6.17a
Sourness	6.25a	6.17a	6.04a
Alcohol	6.38a	6.46a	6.88a
Flavor	6.42a	6.50a	6.62a
General acceptability	6.35a	6.38a	6.33a

[1]Mean scores in a row followed by common letters are not significantly different at 5% level according to DMRT.
[2]Rating scale: (1) weak to (4) strong
[3]Blend of taste: (1) poor blend of alcohol, sweet and sour taste to (5) excellent blend of alcohol, sweet and sour taste
[4]Acceptability: (1) dislike extremely to (9) like extremely

Table 8. Production costs of flavored and non-flavored fermented sweetpotato beverages.[1]

Type of Beverage	Total Production Cost, ₱[2]	Cost, ₱/L
Plain sweetpotato	233.21	11.66
Apple-flavored	472.58	23.63
Chico-flavored	342.58	17.13
Jackfruit-flavored	322.58	16.13
Mango-flavored	417.58	20.88
Orange-flavored	518.58	25.93
Pineapple-flavored	285.22	14.26

[1] Batch process using 3.8-L glass jars at 1 kg roots/jar with 40% fruits; set-up of 10 kg sweetpotato with 20 L of beverage produced. The cost of packaging materials is excluded in the total production cost.

[2] $1.00 = ₱25.00

yielded 20 L of beverage (Table 8). This amount corresponded to ₱25.93/L of beverage excluding the cost of packaging materials. Of all the fruit-flavored beverages, pineapple-flavored was the cheapest with a production cost of only ₱14.26/L. Non-flavored beverage cost only ₱11.66/L.

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