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Chemical Composition and Preservation of Mnazi and Its Distillate (Pyuwa)

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Coconut palm (*Cocos nucifera*) is most well-known for the products of its fruit, such as coconut meat, coconut water, coconut milk, and coconut oil. Almost all edible products of the coconut come from the fruit, or "nut" portion of the plant. Some fruit products include desiccated coconut from the hard endosperm of the seed and toddy which, is produced by tapping the sap from inflorescence. Toddy can be boiled to produce coconut sugar (jaggery) or fermented to become an alcoholic beverage (*Mnazi*). This study explored the quality aspects and preservation of both *Mnazi* and its spirit (pyuwa) with an aim of providing a cheap alternative beverage for both low and middle income earners. The main volatile compounds that were found in both *Mnazi* and its spirit include propanol, isoamyl ethanol butanol and acetic acid. In *Mnazi*, the levels of the volatiles were far much less than 600 mg/l, which is considered the threshold value of acceptability in wine. The absence of methanol and fusel oils in fresh *Mnazi* makes it possible to compete effectively with beers and alcoholic drinks already in the market. However, its distillate (Pyuwa) cannot be recommended as safe alcohol drink unless further separation is done because of its high levels of fusel oils. The newly developed products: dry, medium dry and sweet brands were stable during the first 4 weeks after production. Assimilation of sucrose and fructose were faster than glucose, with fructose being the fastest.

Keywords: Mnazi; coconut palm; preservation; shelf-life.

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1. INTRODUCTION

The coconut palm (*Cocos nucifera*), is the most important palm tree in Kenya. This tree is grown in nearly 90 countries that spread along the tropical coastal belt of the world [1,2].

Coconut wine (*mnazi*) that is widely drank is from the fermentation of the coconut sap obtained by tapping the coconut palm [3]. *mnazi* tapping for beverage is a Pan-tropical practice, but has its great historical depth in Asia and Africa [4]. Tapping and consumption of *mnazi* as a mildly alcoholic beverage at the Coastal region of Kenya has been going on for the last four centuries. Tapping of *mnazi* involves wounding of the stem tissues or tapping from the roots or fruit bud. The tapping process of *mnazi* used in this study was as explained by Kadere et al., [3] while its distillate was traditionally distilled as explained by Kadere, et al., [3].

There are many variations and names of palm wine including: *emu* and *ogogaro* in Nigeria, in Philippines *tuba*, *ra* or *panam culbo* in Ceylon, *tuak* or *nira* in Malaysia, *nsafufuro* in Ghana, kallu in India and *toddy* in Thailand. In Kenya it is commonly referred to as *mnazi,* uchi *wa mnazi* or *mdafu* [3].

Mnazi can be consumed in a variety of flavours varying from sweet unfermented to sour-fermented and vinegary alcoholic drinks. Sweet *mnazi,* for example, is a non-alcoholic drink made from fresh *mnazi*, which is pasteurized before fermentation. A similar drink known as *tembo tamu* is consumed in Lamu district of Coastal Kenya [3].

Wine plays almost an indispensable role in the life of man ranging from social function, religious rites, ritual as well as economic benefits to produce and merchants. In religious sector, wine had been held sacred throughout history [5,3]. Popularity of *mnazi* is evident during traditional celebrations and ceremonies such as marriage, burials and settling of disputes [3]. A similar practice is found in Nigeria. In the Ibo speaking area for example, palm wine is a part of major preliminaries that must be prayed over and discussed before the ceremonies start [6,7].

Previous studies have shown that *mnazi* is an important source of nicotinic acid and vitamin C and to a lesser extent, proteins, thiamine and riboflavin [8]. Apart from direct consumption as an alcoholic beverage, *mnazi* could also be used for leavening of dough [9] or distilled into local gin, popularly known as *Chang`aa* [3].

Generally, spoilt wine affects its taste, odour and visual sensation. This is mainly caused by cork related problems, growth of spoilage microorganisms (yeast or bacteria), sulphur off-odours, exposure to sunlight and temperature extremes [10]. A wide variety of contaminating yeast species have been implicated in wine spoilage as they may dominate when competition by bacteria is hampered by high sugar or alcohol concentrations, low pH values or the presence of some preservatives [10].

In this study, *mnazi* quality and safe *mnazi* products were developed, based on existing information on wine preservation. In previous studies, scientists were able to preserve commercially bottled *mnazi* in sodium benzoate ($C_6H_5.COONa$) at a concentration of 0.15% (m/v). Sodium metabisulphite ($Na_2S_2O_5$) and propionic acid were also found suitable as preservatives but they are less effective [11]. In Thailand, in almost every place, farmers use special barks such as kiam (*Cotyleobium lanceolatum*) and pra-yom (*Shorea floribunda*) for preservation. In some places, a mixture of preservatives is used instead of kiam and pra-yom. This mixture is composed of sodium metabisulphite, sodium propionate ($CH_3.CH_2.COONa$), sodium benzoate in ratio of 10:1:1, respectively [12]. Pasteurization at 85°C for 30min. reduces the viable counts in *Mnazi* to a greater extent than heat treatment at 70°C for 35min. and 65°C for 40min. [13]. European regulations do permit the use of sorbic and ascorbic acids to increase antimicrobial and antioxidant potential in wine. Other products such as Diethyl pyrocarbonate, pimaricin and nisin have been tested but abandoned due to their toxicity or undesirable side effects [14,15].

According to the laws of Kenya (Cap. 122), *mnazi* and its distillate are still being categorized as an “illicit brews”. This notwithstanding, the two alcoholic beverages have been consumed for the last four centuries. It is envisaged that the findings of this study, especially the chemical wholesomeness of *mnazi* and its distillate will provide the appropriate recommendations on categorization of *mnazi* and its distillate.

In Kenya, alcoholic spirit similar to *arrack* known as *pyuwa* is distilled traditionally at the village level from *mnazi* [3].

2. MATERIALS AND METHODS

2.1 Samples for Analysis

Samples of *mnazi* and its distillate that were used for chemical analysis were obtained from Chonyi and Kikambala areas of the Coastal region of Kenya. The samples were collected in sterile sampling tubes. The pH of the sample was determined at the sampling site using a portable pH meter. The samples were kept at 4°C and transported in cool boxes packed with dry ice to the Food Science and Technology Laboratory. To ensure consistency, three tappers and three distillers were selected as sources of the required samples. Their selection was based on their consistency in the way they conducted their tapping and distillation processes. Another factor that was used in the screening exercise was variation in execution of the technology of tapping and distillation. Since earlier survey had indicated little or no variation in the two technologies [3], samples collected from three tappers and three distillers were found to be adequate to provide conclusive results.

2.2 Chemical Composition of Fresh and Preserved *Mnazi* and Its Distillate

The pH was measured using a digital pH-meter after calibration with standard buffers at pH 4.0 and 9.18 respectively. Total Titratable Acidity (TTA) was determined by adding 10g of the sample into 100ml of alcohol 70% (v/v) previously neutralized, followed by 0.5ml of phenolphthalein solution. The mixture was shaken for 1 h followed by filtration. Then 50ml of the filtrate was titrated with 0.1N sodium hydroxide. Fixed acidity was determined by evaporating 50ml of the sample using water bath followed by titration as for TTA. Volatile acidity was determined by calculating the difference between TTA and fixed acidity.

2.3 Determination of Volatile Compounds in the Fresh and Preserved *Mnazi* and Its Distillate

The alcohol content of the samples was determined by distillation method. Specific gravity of the distillate was determined using a pycnometer. The distillate/water ratio was determined and the index corresponding to alcohol percentage (v/v) was determined using the AOAC alcohol tables.

The relative concentrations of volatile compounds: acetaldehyde, ethyl acetate, methanol, 1-propanol, isobutanol and amyl alcohols were determined by Gas Chromatography (Shimadzu GC-9A) using a glass packed column (15% DEGS, 3m length x 3mm internal diameter). The detector used was FID. Nitrogen was used as carrier gas at a flow rate of 50ml/min. The column initial temperature was held at 50°C for 2min. while the final column temperature was held at 150°C for 5min. The programme rate was 5°C/min. During ignition, the air supply was set at 0.2Kg/cm and maintained at 0.5Kg/cm during operation. Samples of 1µl of wine were directly injected into the column and the concentrations of the above mentioned volatile compounds were determined using standard samples. All samples were analyzed in duplicates. 0.1µl each of the standards were injected and the elution time determined. The column temperature was programmed at 3°C/min. The temperatures of the injector and FID detector were each at 220°C. The standards used were: methanol, butan-1-ol, 1- propanol, 2-methyl-1-propanol (isobutyl alcohol), 2-methyl-1-butanol and 3-methyl-1-butanol (Isoamyl alcohol), diethyl ether, ethoxy ether, acetaldehyde and 4-propanol. The absence of methanol in the tested samples was confirmed using the Deniges test Method. Using Schiff's reagent, the presence of methanol was determined through colour change, which is the colour of the resulting mixed solution. Presence of violet colour within a few minutes was considered positive result, while delayed colour change up to about 30min. indicated presence of methanol but only in traces.

The following formula was used to determine the concentration of volatiles using the gas chromatographic method:

$$C = \left[\left(\frac{A_p C_a}{A_t \times 100} \right) \rho \times 10^6 \right]$$

Where: C - concentration [ppm]; A_p - peak area of the compound; C_a - alcohol content; A_t - total area of all peaks; ρ - the density of the solvent.

The presence of sugars such as sucrose, glucose, and fructose was analyzed using HPLC chromatographic method. Standard solutions dissolved in acetonitrile were each injected (10µl each) and the elution time of each standard was noted. The prepared samples were mixed with acetonitrile in the ratio of 1:1, stored under

refrigeration before injection. The column used for analysis was Shodex NH2 P-50 4E, the mobile phase used for elution was acetonitrile: water (75:25). The oven temperature was maintained at 35°C with a flow rate of 0.8ml/min.; the pressures were maintained at 98-100 Kilogramme-forces (Kgf) during analysis.

The presence or absence of anions in fresh *mnazi* was confirmed using the Agilent Basic Anion Buffer System (ABABS). The ABABS uses the principle of that allows migration of both the anion and Electroosmotic flow (EOF) in the same direction. First, a highly alkaline pH condition is used to confer and promote migration of a negative charge of inorganic and organic anions as well as amino acids and carbohydrates towards the anode and past the detector. To reverse the EOF so that migration can be towards the anode, a quaternary ammonium salt was used. The sample was diluted with deionized water in the ratio of 1:50 and an indirect UV detection was employed to visualize anions which had little or no chromophore. A capillary made of fused silica with id = 50µm, l=104cm and L =112.5cm (G1600-64211) was used. The capillary temperature was 15°C, while the applied voltage was at -30 kV, injection conditions were: 1). Pressure: 50 mbar for 6 seconds from sample vial; 2). Post-injection of buffer from In Home vial, 50 mbar for 4 seconds. The detection wavelength was: Signal 350/20nm, reference 230/10nm. Preconditioning was done using buffer flush for 4min at 1bar prior each run.

2.4 Preservation Technique for Newly Developed Products

Freshly tapped *mnazi* was blended with that which had been allowed to ferment for a period of 8-12h so as to enhance quality of the final product. The blended *mnazi* was then pasteurized at different time-temperature combinations (65, 75 and 80°C for 40, 35 and 30min., respectively). After pasteurization, the coded samples were cooled in stainless steel vessels that were immersed in a basin of cold water to a temperature between 40 and 60°C. Finally, the samples were poured in clean sterilized plastic bottles with similar codes which contained sodium benzoate (0.25, 0.5, 0.75% (m/v) depending on the sample) or a mixture of sodium benzoate and sodium metabisulphite, as shown in the Table 1. The filled bottles were then closed and sealed, followed by mixing through thorough shaking of the contents in sealed bottles for 5-10min. so as to dissolve the preservatives. For the control, some samples of the blended *mnazi* were neither pasteurized nor preserved by chemicals. Shelf life was determined to all samples.

2.5 Determination of Shelf Life of the Preserved Products

For shelf life, eight bottles were picked from each preserved and coded samples. Four bottles of each coded sample were stored at 04°C while the remaining four bottles were stored at room temperature for a period of 2 months. During storage, acidity, pH and sugar levels were monitored for a period of 2 months.

Similarly, 8 bottles of the control sample (non-preserved freshly tapped *Mnazi*) were preserved as explained above, four under refrigeration and the other four at a room temperature. The parameters (acidity, pH and sugar levels) were monitored for period of one week.

Table 1. Preservation conditions of various developed products

Sample codes	Sodium benzoate (% m/v)	Temperature (°C)	Pasteurization time (Min)
A1	0.25	85	30
A2	0.25	75	35
A3	0.25	65	40
B1	0.5	85	30
B2	0.5	75	35
C1	0.75	85	30
C3	0.75	65	40
C-65	Non	65	40
C-75	Non	75	35
D1*	10:1	75	35
D2**	1:1	75	35

**sodium benzoate and sodium metabisulphite in the ratio of 10:1 (0.25% ( ):0.025% ( )); **sodium benzoate and sodium metabisulphite in the ratio of 1:1 (0.25%)*

2.6 Chemical Preservation of the Newly Developed Products

In addition to the combined preservation technique (preservation by both chemical and pasteurization), a method to preserve *mnazi* by chemical preservatives alone was developed based on the fact that fruit wines may be preserved without undergoing pasteurization. Initial trials of the preserved products were done, in which four (4) samples of each product were stored at both refrigeration and room temperatures. After observing that the products were very stable within the two weeks of trials, three brands were developed namely: "Dry", "Medium Dry" and "Sweet" brands based on the level of fermentation. To improve on the packaging material, translucent glass bottles were used. Labels for the products were designed, that incorporated culture and the Coastal Kenya background. A different design was used for each brand as shown in Fig. 2.

2.7 Determination of Shelf Life of the Preserved Products

The shelf-life of the three brands was determined as stated above. Parameters such as acidity, pH and sugar levels were monitored during storage for a period of 2 months.

Procedures for the development of three preserved toddy brands:- Sweet, Medium Dry and Dry as shown below:

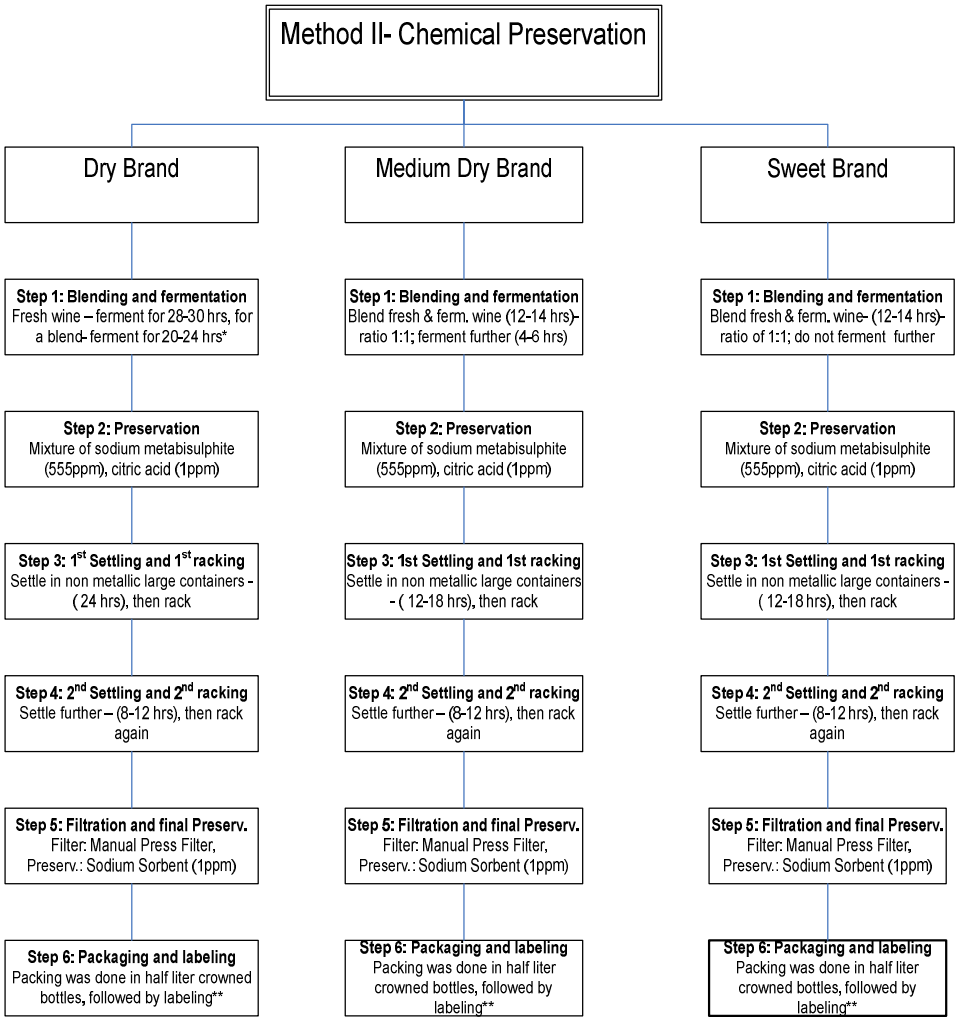


Fig. 1. Systematic steps for the development of three brands: sweet, medium dry and dry *mnazi* products (using chemical preservatives)

Fig. 2. Design models of potential labels of the developed products showing different brands and different packaging materials

3. RESULTS AND DISCUSSION

The changes in alcohol content, pH and acidity in freshly tapped *mnazi* during storage at room and refrigeration temperatures are shown in Tables 2 and 3, respectively.

From the results, freshly tapped *mnazi* had an alcohol content of about 6% (v/v). The alcohol content and acidity increased gradually with time during storage while pH decreased (Tables 2 and 3). The alcohol content in freshly tapped *mnazi* stored at room temperature reached a maximum (7.1 and 7.5 % (v/v) for tappers 1 and 2 respectively) on day 4, before gradual decline. However, acidity kept on increasing without a maximum, making pH to decrease gradually too. Freshly tapped *mnazi* collected from tapper 1 and stored at 25°C, had its alcohol content increase from 5.8 to 7.1% (v/v), while that from tapper 2 increased from 5.1 to 7.5% (v/v) as shown in Table 2.

Freshly tapped *mnazi* stored at 04°C had its alcohol content increase gradually from 5.8 to 6.6% (v/v) and 5.9 to 6.7% (v/v) for tappers 1 and 2, respectively Table 3.

Changes in alcohol content, acidity and sugar levels in the newly developed wine products

during storage are provided in Tables 4 and 5. From the results; there is a correlation between increase in alcohol content and decrease of common sugars found in *mnazi*. Samples prepared using the first method (Method1) showed stability only during the first 4 weeks of storage irrespective of the storage conditions (Table 4). On further storage, significant changes were observed between 6th and 8th week of storage. However, products such as A2, A3 and C65 showed significant changes, including gas formation within 4th week of storage (Table 4). The results show that sucrose and fructose were assimilated faster than glucose, with assimilation of fructose being the fastest (Table 4 and 5). All samples produced gas at the end of 8th week except D2 and indicator that fermentation was taking place during storage. The gradual increase in alcohol content throughout the storage period confirms this assumption.

Tables 6 and 7 show how acidity and other volatile components in *mnazi* and its distillate vary depending on the source. From the results fresh *mnazi* did not register any fusel oil. Whereas *Mnazi* that had stayed for at least four days showed some traces of fusel oils.

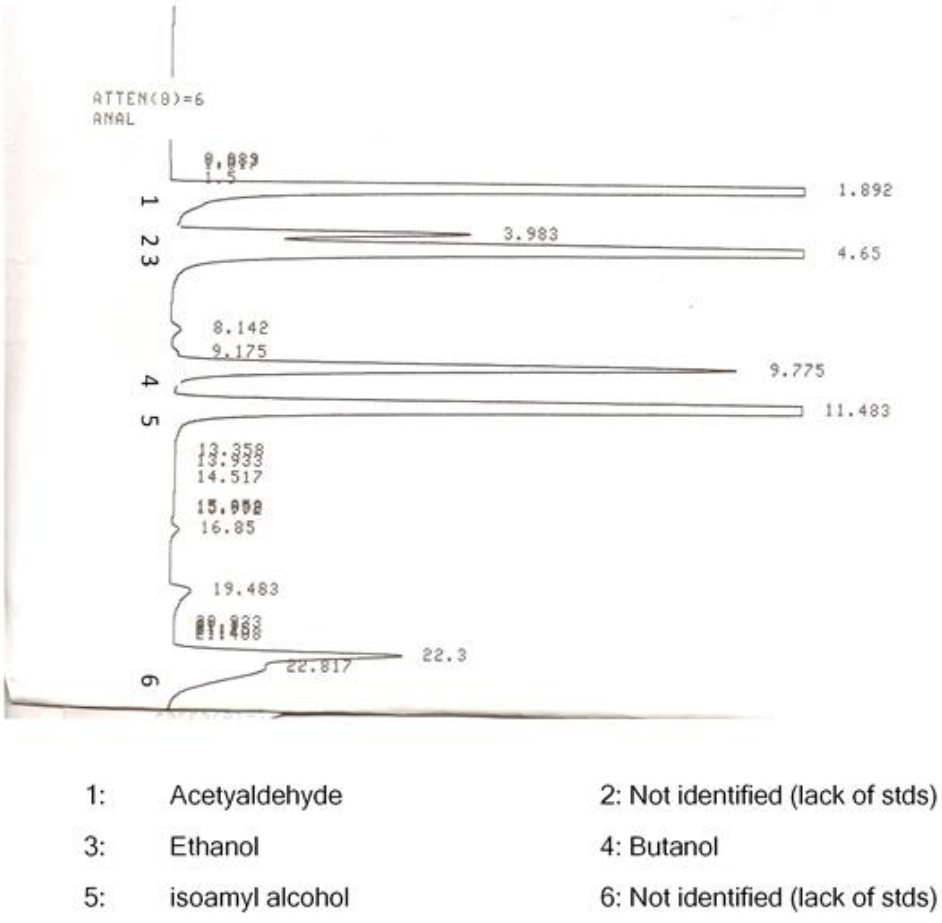
There were significant levels in the distillate (Fig, 3). A quick profile by the Basic Anion Buffer System (ABABS) method confirmed the presence of glucose, lactose, fructose and sucrose in *mnazi*. Other anions whose presence was confirmed included: chlorides, acetate and lactate (Fig. 4). *Mnazi* has for a long time been consumed as a traditional alcoholic drink at the Coastal region of Kenya, without proper hygienic packaging and preservation. As a result of this practice tappers and traders (*wachuuzi*) alike have incurred a lot of losses in terms of wastage and poor prices due to short shelf life of *mnazi*. Under special circumstances, some local distillers tried to distill it into spirit as explained by Kadere et al. [3]. However, since *mnazi* is still considered as an "illicit brew", the challenges and constraints explained Kadere et al. [3] act as impediment to promotion and utilization of *mnazi* and its spirit.

This study revealed that *Mnazi* had a very short shelf life (1-2 days) if proper preservation techniques are not employed. This could be attributed by the vast different types of micro-flora found naturally in *Mnazi* [16,17](Kadere and Kutima 2015). In addition, its chemical composition makes it a suitable substrate for the natural micro flora. These microorganisms are capable of fermenting sugars and other bi-products of fermentation with the release of volatile and flavour compounds such as organic acids, esters, ethers and fusel oils. Romano et al., [18], reported that both *Saccharomyces* and non-*Saccharomyces* yeasts contribute significantly to the flavour and quality of wine. According to Pretorius, [19], volatile profile of wines is dominated by those components that are formed and retained most during fermentation, since these compounds are present in the highest concentrations.

In this study, *mnazi* fermentation by both methods was allowed to take place at room temperature except when it was stored at refrigeration temperature. Previous studies, however, have shown that wines produced at low temperatures (10-15°C) have a tendency to develop certain characteristics of taste and aroma [20], in addition to improved quality due to fewer higher alcohols and a greater proportion of acetate and ethyl esters among the total volatile compounds [21]. In addition, low temperatures reduce the growth of acetic and lactic acid bacteria and this can make it easier to control alcoholic fermentation. However, the optimal growth temperature for *Saccharomyces cerevisiae* is 25°C, while 13°C is restrictive and increases the risks of stuck or sluggish fermentations [22]. Low temperatures increase the duration of alcoholic fermentation, decrease the rate of yeast growth and modify the ecology of wine fermentation. The main volatile compounds that were found in both *mnazi* and its spirit include propanol, isoamyl ethanol butanol and acetic acid. In *mnazi*, the levels of the volatiles were far much less than 600 mg/l, which is considered the threshold value of acceptability in wine (Romano, 1990). The fact that no traces of methanol were detected in *mnazi* qualifies it further as safe drink. As shown in Table 7, *mnazi* meets all the Kenya Bureau of Standards specifications for fortified wines (KS1122:2007), still table wine (KS 05-609:1990) and sparkling wines (KS 05-1121:1994). These findings can therefore be used as a justification to policy change that aims at exclusion of *mnazi* from the category of "illicit brews" hence making it a legal product. Once this is achieved, promotion of this product could be given priority with emphasis on hygienic packaging and preservation. As for the *mnazi* distillate (*pyuwa*), all the volatile compounds analyzed were within the 600ppm threshold except isoamyl alcohol, which was above 600ppm in two out of the three samples analyzed. Methanol was not detected in all the three samples of *mnazi* distillate. According to

International Programme on Chemical Safety (IPCS), iso-butanol is considered slightly toxic and has been shown to cause liver damage in mice and human at a threshold of 100 ppm. Propanol causes drowsiness, gastrointestinal pains, and nausea, and may be even lethal if the threshold is above 400ppm. Iso-amyl alcohol has similar health effect including irritation on the eye, nose, throat, skin and mild narcosis if the exposure is above 100ppm. Based on these findings consumption of *mnazi* distillate commonly referred to as *pyuwa* is not recommended on the basis of these alcohols.

In this study, two methods were employed with an aim of prolonging the shelf life of *mnazi* and at the same time ensuring hygienic packaging and handling. The products developed using method-2 above were more stable compared to those developed using method-1 (Tables 4 and 5). Preservation by method-1 used a combination sodium benzoate and pasteurization. Pasteurization at 65 °C was found to be less effective than that at 75 °C (Table 4). Similarly use of sodium benzoate and sodium metabisulphite in the ratio of 10:1 was found to be less effective than a ratio of 1:1 (Table 4). The differences in in shelf-life between Method-1 and Method-2 could be attributed, partly by the packaging material (translucent glass bottles) and partly by the method employed. The fact that our products could not keep longer than 2 months (normally preserved and well packaged wines and beers have a shelf life of more than three months) could be attributed to the type and conditions of filter unit employed. In this study, a leaky manual press filter was used because others were not available. In addition, the filter medium (membrane) was used repeatedly because new supplies were not available locally. However, the results obtained were convincing enough.



1:	Acetyaldehyde	2: Not identified (lack of stds)
3:	Ethanol	4: Butanol
5:	isoamyl alcohol	6: Not identified (lack of stds)

Fig. 3. Gas chromatography eluting profile of the volatile compounds in *mnazi* distillate

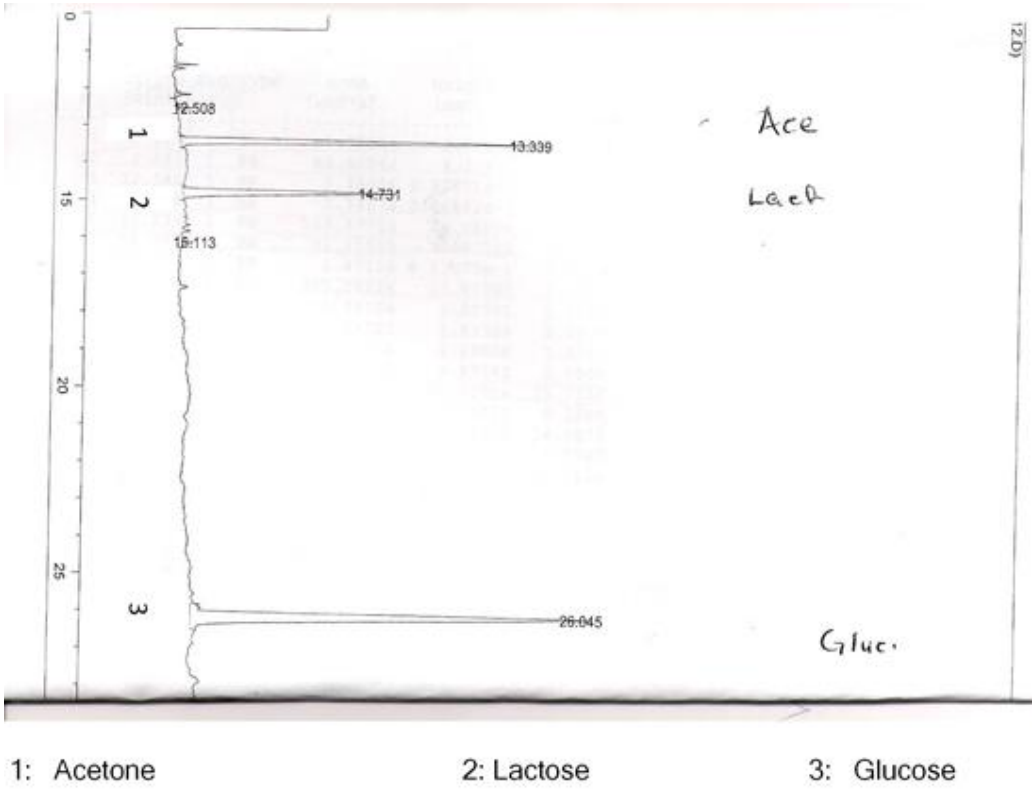


Fig. 4. Gas chromatography eluting profile of the volatile compounds in *mnazi* distillate

Table 2. Changes of alcohol content, acidity and pH of freshly tapped *mnazi* during storage at room temperature (25°C)

Storage Time(Days)	Tapper 1			Tapper 2		
	Alcohol Cont. (v/v)	Acidity % (v/v)	pH	Alcohol Cont. (v/v)	Acidity % (v/v)	pH
1	5.80	0.24	4.00	5.90	0.25	3.90
2	6.80	0.31	3.80	6.90	0.39	3.85
3	7.00	0.39	3.75	7.32	0.41	3.77
4	7.10	0.42	3.61	7.50	0.49	3.69
5	6.80	0.48	3.50	7.30	0.52	3.54
6	6.75	0.59	3.36	7.0	0.61	3.39

Table 3. Changes of alcohol content, acidity and pH of freshly tapped *mnazi* during storage at 04°C

Storage Time(Days)	Tapper 1			Tapper 2		
	Alcohol Cont. (v/v)	Acidity % (v/v)	pH	Alcohol Cont. (v/v)	Acidity % (v/v)	pH
1	5.80	0.24	4.00	5.90	0.25	3.90
2	5.90	0.28	3.85	6.00	0.30	3.86
3	6.13	0.28	3.86	6.32	0.31	3.86
4	6.30	0.28	3.80	6.40	0.31	3.86
5	6.40	0.29	3.80	6.52	0.32	3.79
6	6.60	0.33	3.70	6.70	0.35	3.72

Table 4. Alcohol content, pH and sugar levels during room temperature storage of the preserved *mnazi* alcoholic products in plastic bottles

Sample codes	pH Value				Alcohol (%)				Glucose (mg/g)			Fructose (mg/g)			Sucrose (mg/g)			Storage Condn.	
	0w	4w	6w	8w	0w	4w	6w	8w	4w	6w	8w	4w	6w	8w	4w	6w	8w	4w	8w
A1	4.24	4.23	4.10	3.80	3.98	3.99	4.52	6.07	41.74	10.60	7.48	3.52	0.00	0.00	43.14	8.88	0.01	NG	G++
A2	3.71	3.70	3.69	3.67	3.77	3.77	4.24	5.01	61.23	30.23	27.05	17.23	1.34	6.08	266.00	36.00	0.00	G+	G++
A3	4.31	4.30	3.90	3.73	3.27	3.27	3.55	4.64	37.05	9.96	7.54	4.35	2.00	1.32	106.34	15.65	0.01	G+	G++
B1	4.37	4.37	4.00	3.70	4.64	4.64	4.73	4.97	37.96	34.6	33.60	19.06	1.09	0.00	0.22	0.00	0.00	NG	NG
B2	4.61	4.60	4.11	4.03	3.77	3.77	4.12	5.46	67.92	37.95	29.09	14.16	8.23	7.54	372.55	1.00	0.67	NG	G++
C1	4.50	4.47	4.00	3.97	3.34	3.34	3.86	5.46	53.86	30.76	20.98	3.81	0.00	0.00	0.06	0.00	0.00	NG	G++
C3	4.27	4.27	3.99	3.77	3.77	3.77	4.64	6.07	55.81	8.90	4.24	0.29	0.00	0.00	0.00	0.00	0.00	NG	G++
C-65	3.89	3.87	3.64	3.17	8.65	9.15	9.92	10.93	26.76	1.00	0.00	2.77	0.00	0.00	0.00	0.00	0.00	G++	G++
C-75	4.04	4.03	3.99	3.90	5.20	5.23	5.99	6.38	48.59	38.96	33.49	0.00	0.00	0.00	0.01	0.00	0.00	NG	G+
D1	4.20	4.20	4.08	3.90	3.74	3.77	4.32	6.30	5.64	0.59	0.00	0.38	0.00	0.00	0.00	0.00	0.00	NG	G++
D2	4.48	4.47	4.11	3.80	3.56	3.56	3.88	4.42	56.31	15.09	7.53	18.67	4.08	6.03	105.45	5.89	2.05	NG	NG

0w – Tests conducted 2 days after bottling; 4w, 6w, 8w – Tests conducted after 4, 6 and 8 weeks respectively; NG - No gas production; G+ - Little gas produced; G++ - high quantity of gas produced

Table 5. Alcohol content, pH and sugar levels during storage at room and refrigeration temperatures of the preserved *mnazi* alcoholic products in glass bottles

Sample codes	pH Value				Alcohol (%)				Glucose (mg/g)			Fructose (mg/g)			Sucrose (mg/g)			Storage Condn.	
	0w	4w	6w	8w	0w	4w	6w	8w	4w	6w	8w	4w	6w	8w	4w	6w	8w	4w	8w
SW04	4.10	4.09	4.09	4.00	5.01	5.22	5.25	5.33	65.00	64.66	55.70	6.00	5.99	5.77	264.06	264.00	263.90	NG	G+
SW25	4.10	4.00	4.00	3.98	5.01	5.30	5.36	5.43	65.00	63.99	60.09	6.00	5.45	5.00	264.06	263.88	263.00	NG	G+
MD04	3.90	3.89	3.83	3.80	5.84	5.89	5.94	5.99	40.38	39.00	37.00	3.56	3.00	3.00	110.93	110.23	110.02	NG	NG
MD25	3.90	3.86	3.80	3.77	5.84	5.95	5.99	6.01	40.38	37.88	332.99	3.56	2.56	2.50	110.93	109.98	109.88	NG	NG
D04	3.38	3.37	3.36	3.30	7.91	7.99	8.00	8.03	25.00	24.67	23.89	0.00	0.00	0.00	45.12	45.00	44.09	NG	NG
D25	3.38	3.36	3.30	3.22	7.91	8.02	8.12	8.33	25.00	23.99	20.24	0.00	0.00	0.00	45.12	44.79	40.99	NG	NG

0w – Tests conducted 2 days after bottling; 4w, 6w, 8w – Tests conducted after 4, 6 and 8 weeks respectively; NG - No gas production; G+ - Little gas produced; SW04, SW25-Sweet brands stored at 04 ºC and 25 ºC respectively; MD04, MD25- Medium Dry brands stored at 04 ºC and 25 ºC respectively; D04, D25 – Dry brands stored at 04 and 25 ºC respectively

Table 6. Composition of volatile substance and relative concentrations of fusel oils in mnazi distillate (Pyuwa) from three different distillers

Parameter	Dist. 1	Dist. 2	Dist. 3	Mean	STDEV	SKEW
Volatile acidity % (v/v)	0.03	0.03	0.03	0.03	0.001	1.732
Acetic acid % (v/v)	0.05	0.05	0.04	0.05	0.006	-1.732
Esters (mg/100 ml ethanol)[1]	0.06	0.07	0.07	0.07	0.004	-1.293
Aldehydes (mg/100 ml ethanol)[2]	0.02	0.05	0.05	0.03	0.154	-1.090
Ethanol % (v/v)	44.62	37.81	36.33	39.59	4.421	1.513
Methanol[3]	n.d.	n.d.	n.d.	n.a.	n.a.	n.a.
Acetaldehyde[3]	16.85	34.41	n.d	25.63	12.42	n.a
Propanol[3]	n.d	83.15	58.34	70.75	17.54	n.a
Isoamyl ethanol[3]	881.30	682.09	346.12	636.50	270.49	0.74
Butanol[3]	n.d	n.d	n.d	n.a	n.a	n.a
Iso-butanol[3]	222.37	130.04	101.00	151.14	63.38	1.33
*RT 17.64[3]	139.79ρ	175.31ρ	218.74ρ	n.a	n.a	n.a

*[1]at temperature 70-80 °C, results expressed as acetyl acetate; [3] ppm on the basis of absolute alcohol; *unknown- unable to determine based on standards used, ρ= desity of compound to be identified; 'n.a' =not applicable, 'n.d'= Too low to be detected by this method*

Table 7. Relative composition of volatile substance and fusel oils in freshly tapped *mnazi* based on samples collected from three different tappers

Parameter	20- 24 hrs after tapping			4 days after tapping					
	Tap. 1	Tap. 2	Tap. 3	Tap. 1	Tap. 2	Tap. 3	Mean	STDEV	SKEW
Total acidity % (v/v)	0.59	0.58	0.60	0.69	0.63	0.70	0.63	0.047	0.624
Fixed acidity % (v/v)	0.33	0.34	0.34	0.43	0.44	0.48	0.39	0.059	0.315
Volatile acidity % (v/v)	0.26	0.24	0.26	0.32	0.34	0.36	0.30	0.045	0.125
Acetic acid % (v/v)	0.63	0.57	0.62	0.66	0.67	0.69	0.64	0.039	-0.746
Ethanol % (v/v)	6.18	6.30	6.25	6.88	6.90	6.70	6.54	0.030	0.104
Methanol[3]	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.a	n.a	n.a
Acetaldehyde[3]	n.d.	n.d.	n.d.	0.01	0.01	n.d.	0.00	0.006	-1.732
Propanol[3]	n.d.	n.d.	n.d.	0.03	0.01	0.02	0.01	0.010	0.855
Isoamyl ethanol[3]	n.d.	n.d.	n.d.	0.23	0.25	0.12	0.1	0.076	0.000
Butanol[3]	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.a	n.a	n.a
RT8.05[3]	n.d.	n.d.	n.d.	0.04	0.06	0.04	0.02	0.016	0.000
RT 17.64[3]	n.d.	n.d.	n.d.	0.05	0.03	0.06	0.02	0.007	Infin.

1at temperature 70-80°C, results expressed as acetyl acetate; [2] experiment done at and the results are expressed as acetaldehyde; [3] ppm on the basis of absolute alcohol; 'n.a' =not applicable, 'n.d'= Too low to be detected by this method; infin- #Div/0

4. CONCLUSION

From the finding, glass bottles were found to be better packaging materials for *mnazi* than plastic bottles. Preserved *mnazi* was able to keep for more than two months without spoilage. On the wholesomeness of both the *mnazi* and its distillate, only the *mnazi* was found to be successful, hence the author recommends it. This was based on the fact that it was free from methanol and the levels of other volatile compounds (fusel oils) were less than 100ppm. However, its distillate was found to be unsafe for human consumption despite the fact that methanol levels were insignificant. Based on these findings, only *mnazi* meets the required specifications for beers, wines and spirits according to the specifications of KEBS. This therefore calls for the need to de-gazette it from the category of "illicit brews". *Mnazi* distillate (*pyuwa*) however registered higher content of isoamyl alcohol than the recommended limits. It is against this background that the author does not recommend de-gazetting of *mnazi* distillate (pyuwa) from the category of "illicit brews" unless the distillation technology is improved.

DISCLAIMER

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products (Tappers and Distillers) because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by any producing company rather it was funded by then Kenya Agricultural Research Institute (KARI), under Agricultural Research Fund (ARF).

COMPETING INTERESTS

Author has declared that no competing interests exist.

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