

## THE UNDER-EXPLOITED INDIGENOUS ALCOHOLIC BEVERAGES OF TANZANIA: PRODUCTION, CONSUMPTION AND QUALITY OF THE UNDOCUMENTED "DENGE"

H. S. LASWAI

*Sokoine University of Agriculture, Department of Food Science & Technology*

A. M. WENDELIN

*Sokoine University of Agriculture, Department of Food Science & Technology*

N. KITABATAKE

*The Research Institute of Food Science, Kyoto University*

T. C. E. MOSHA

*Sokoine University of Agriculture, Department of Food Science & Technology*

**ABSTRACT** In Africa, there are numerous traditional alcoholic beverages. Unavailability of literature on these beverages, particularly regarding their production, consumption and quality is a major constraint against industrial production. The rising prices of conventional alcoholic beverages call for more studies on these beverages. "Denge," one such beverage, was studied and analyzed in terms of total soluble solids, specific gravity, pH and titratable acidity changes during fermentation.

Results showed that *Kigelia africana* and *Aloe pluridens* were used to prepare fermenting agents for subsequent production of "denge," acting primarily as a reservoir of micro-organisms for this fermentation. Slime formation in the raw cane juice was a common problem. Optimum time for heat sterilisation of the juice, a possible method to be used by ordinary households need to be established. Types and numbers of microorganisms in the fermentation need identification. Types and levels of residual toxicants from *K. africana* and *A. pluridens* in the wine need to be documented. The specific gravity, total soluble solids, pH and titratable acidity studies have displayed the perishability of "denge" during storage. More shelflife studies are recommended.

**Key Words:** Denge; Alcoholic beverage; Tanzania; *Kigelia africana*; *Aloe pluridens*.

### INTRODUCTION

"Denge" or "dengelua" is an alcoholic beverage of the Pare tribe in Tanzania. It is manufactured from sugar cane juice or cane sugar solution, using specially prepared fruits of "Mkisha" (*Kigelia africana*) or stem of "Kisapa" (*Aloe pluridens*) plants. A similar drink is produced by other tribes in the country, where it is known as "boha" and "kitwange" by the Sambaa and Kaguru tribes, respectively. Such traditional alcoholic beverages including "mbege" from bananas and finger millet, "ulanzi" from bamboo juice fermented with wild yeast, "kangara" from yeast-fermented honey and "rubisi" brewed from banana and sorghum, again with wild yeast, are increasingly popular. This is particularly so for the low-income population that

forms a big segment of the total population. Reports of use of *Kigelia africana* (*K. aethiopum*) fruits in fermentation have been made in some other countries in Africa (Gachathi, 1989).

Sugar cane wine is widely made in the eastern portion of Congo basin. The juice is mixed with barks and leaves of unidentified species of trees and the juice is left to set six hours or until foam ceases to come out, strained and drunk. The end of fermentation is difficult to judge (Peterson, 1965). "Denge" producers face the same difficulty and unless scientific methods of judging the right time when this fermentation has to be arrested is established, industrial production of this beverage will certainly face problems in the quality of the finished product.

With the increasing population pressure, declining household income and still high demand for alcoholic beverages in villages and the unaffordability of the commercial beer, the proportion of cereals diverted from food to the brewing sector is becoming significant. This situation therefore highlights the growing role of brewing in causing household food insecurity. Unless immediate intervention measures are taken to protect these cereals, which are the main sources of food in most households, malnutrition resulting from inadequate energy and nutrient intakes is inevitable. It is practically impossible to ban consumers from drinking since it has been a part of their life. In addition, the beverage provides calories, vitamins, particularly of the B group, and other inorganic salts and minerals such as K, Na, Ca, Mg, P, Fe, and Cu. (Amerine *et al.*, 1980; Paul & Southgate, 1978). Therefore, one possible way to minimise the portion of cereals used for brewing is to explore non-cereal sources for brewing. In many places where sugar cane is not grown industrially, it is insignificant as food source. Jaggery production is presently gaining popularity in some places including the Korogwe district. Juaggery could serve as source of raw sugar for the brewing.

"Denge" is one of such traditional alcoholic beverages whose popularity has remained localised in the villages of origin despite the obvious opportunities for its industrial production. With limited literature on this beverage, this study was conducted to collect baseline information of the beverage production, consumption and quality. This study provides, the background information necessary in the upgrading of this traditional technology in the long run. In addition, the study will help to diversity sources of raw materials used for industrial brewing in Tanzania. This move will also add to the variety of Tanzanian alcoholic beverages.

## MATERIALS AND METHODS

Cane sugar was purchased from a Morogoro supermarket. Freshly extracted cane juice was purchased from a private vendor in Morogoro town.

Freshly prepared stem of *Aloe pruden*s (Fig. 1) and fruits of *Kigelia africana* (Fig. 2) were obtained from Mwangi district in Kilimanjaro region. Distilled water was used for diluting the sugar cane juice and for making the cane sugar solution.

The reagents used in this study were all of analytical grade and included sodium hydroxide and phenolphthalein indicator. Specific gravity (S.G.) was determined using specific gravity bottle.

Total soluble solids in °Brix (g/100 ml solution) were determined by refractometer (OTAGO), calibrated at 20°C. Total acidity was obtained by titration of a 20 ml of sample with 0.1 N NaOH using phenolphthalein as indicator. This total acidity was then calculated as percent acetic acid (w/v) as per Amerine and Ough (1974). The calculation was from the relationship:

$$\% \text{ acetic acid} = \frac{\text{Titre} \times \text{Normality} \times \text{Dilution factor} \times 60 \times 100}{1000 \times \text{Volume of sample}}$$

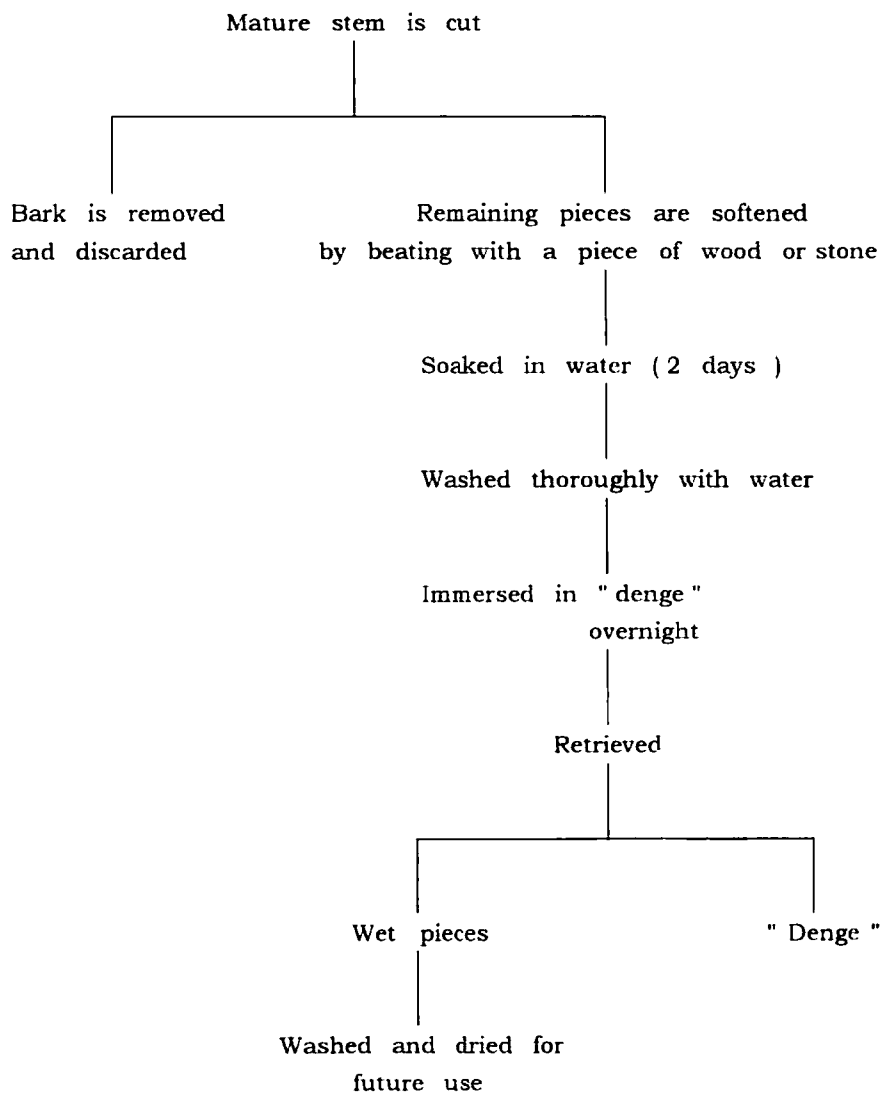


Fig. 1. Preparation of *A. pluridens* for use as fermenting agent in "denge" production.

The pH values were read directly from the pH meter calibrated with pH 7.0 buffer at 20°C.

To recreate the household brewing method, cane juice was pasteurised at 100°C for 10 minutes to inactivate the microorganisms, which cause slime production in the juice prior to processing. This juice was then cooled to room temperature before adjusting the total soluble solids to 17.8 °Brix (i.e., % solids, mostly sugar expressed in g/100 ml juice).

The two sources of fermentable sugars were separately mixed with the specially prepared fermenting agents at room temperature as indicated in Table 1. The trend during fermentation was followed by monitoring specific gravity, total soluble solids, pH and total acidity. Two controls were incorporated, namely the unpasteurized cane juice and the pasteurized juice treated with *Kigelia* fruit fermenting agent. To all treatments, equal weights (89.5 g) of fermenting agent were added. The treatments were as shown in Table 1.

## RESULTS AND DISCUSSION

### I. Sugar Cane Juice or Cane Sugar

In “denge” production, the raw materials are sugar cane juice or cane sugar, fermenting agents (plant parts) and water. Sugar cane juice is the one most common source of fermentable sugars. Limited information is available on the safety of the raw materials used in the production as well as of the finished product. This area warrants investigation, especially on the toxicological aspects of “denge” production and consumption. Use of cane sugar in the processing is often an alternative to the cane juice when it is not available. Alternatively, sugar is used when the juice is too diluted, as in the rainy season when sugar cane pulp has too much water that dilutes the sugar content, or when the cane is immature. In such circumstances, cane sugar has to be added to increase total solids so that when fermented, the product will have relatively high alcohol content. On the whole, cane sugar is usually more expensive than the juice, a fact that adds to the preference for the juice in brewing.

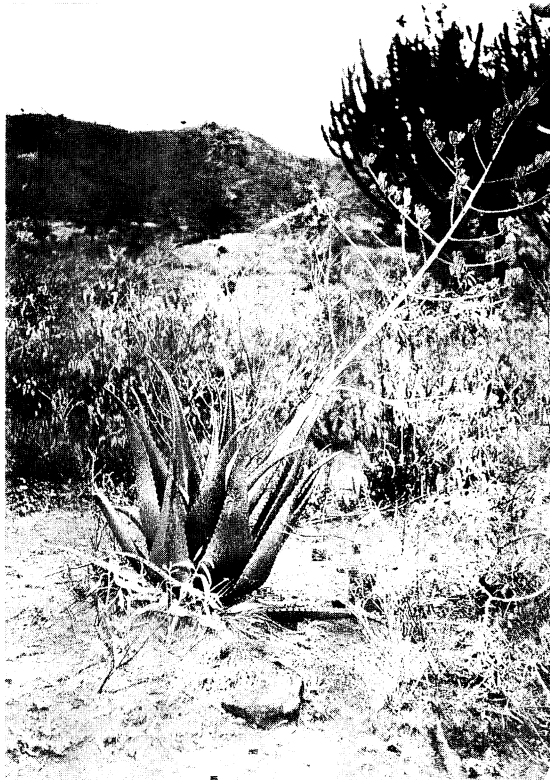
It is further reported by the professional “denge” makers that their customers prefer “denge” that is made from the juice as it has a relatively better taste and appearance. Some contents in the raw sugar cane juice seem to contribute positively to the taste of “denge.”

### II. Water

The water used in the brewing is either obtained from the tap, river or stream. Normally, since this is not purified water, the practice highlights the possibilities of encountering high counts of micro-organisms, some of which could be pathogenic or could produce toxins in the finished product. Again, this area calls for more investigation to establish levels and types of microbial contamination of the “denge.” Such information would prove useful for consumer protection and could serve as a food quality guide to the industrialisation of indigenous brewing.



**Fig. 3.** *Kigelia africana* plant ("Mkisha") (Source: Kisangara Village, Mwanga district).



**Fig. 4.** *Aloe pluridens* Plant ("Kisapa") (Source: Kisangara Village, Mwanga district).

### III. Fermenting agents

“Mikisha” or “Mukisha” (*Kigelia africana* or *Kigelia aethiopum* or sausage tree) (Fig. 3) has several names in different languages. These include “muratina” (Meru), “muatini” (Kamba), “mvunganya,” “mvungavunga” or “mwegea” (Swahili) and “mkisha” (Pare). It is a tree of the family Bignoniaceae, whose fruits are prepared and then used in fermentation of sugar cane juice to produce “denge.” The unripe fruits of this plant are poisonous. Slices of mature baked fruits are used to ferment or flavour African beer. The fruit bark is also used as medicine (Gachathi, 1989).

Seeds of the kigelia plant are partly roasted and placed in the beverage, but if left in too long render the drink poisonous (Verdcourt & Trump, 1969). It has been also reported that the seeds are used in the brewing to enlarge the sexual organs. Reports of criminal poisoning have been made. The reason for roasting the seeds is not clear, although it is believed that roasting facilitates exposure of the fibres during preparation of the fermenting agent. In addition, the literature highlights possibilities of health risks from the toxicants likely to be found in the beverage.

Watt and Breyer-Brandwijk (1962) further elaborated that the fruit of *Kigelia aethiopica* Decne is used as an intoxicant and sexual excitant and in the treatment of wounds. The fruit is often added to the beverage to increase its strength through increased fermentation. Drinking this beverage often causes severe headache, which may be due to the formation of amyl alcohol. The bark contains bitter principle and tannic acid, and the plant is said to be toxic under certain conditions.

“Kisapa” (*Aloe pluridens* or *A. volcance*) (Fig. 4) is of the Liliaceae family, known for containing aloin, a chemical that is useful in burn treatment, X-ray and insect repellent (Cubitt, 1974). Traditionally, the leaves are used as medicine for the ears, and the roots, for stomachache (Namwaka, 1994; personal communication). There is a need to establish the most effective way of preparing the fermenting agents, to identify types of associated toxicants, optimum levels of the agents to maximise alcohol production, and to enhance taste and overall acceptability of the beverage. The fermenting agents can be reused more than ten times and can keep for years.

*Aloe volcance* was the most common fermenting agent in most households due to ease in preparation, low cost, long shelf life and good flavour. *Kigelia africana* was very effective in the fermentation, inexpensive and easily available but was difficult to prepare and had short shelf life. Freshly prepared fermenting agents were less effective than those that had been used for more than three times. However, older ones were also less effective.

### IV. Process

The process followed in production of “denge” is shown in Fig. 5. Generally, most of the operations are manual, with the exception of juice extraction that used either a manually- (Fig. 6) or electric-operated (Fig. 7) extraction machine. On the average, the wooden manually-operated machine takes six times the amount of time required to produce a unit quantity of juice when compared with the electric extractor. The wooden machines are still more popular because of their availability, low

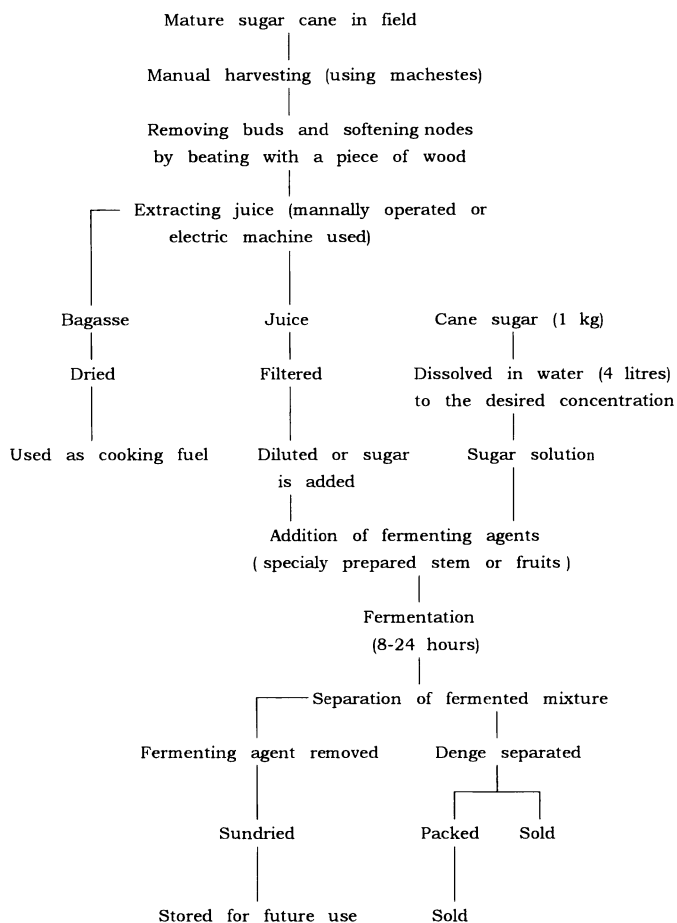


Fig. 5. Flow diagram of "denge" processing.

cost and freedom from reliance on electricity, whose availability is a problem in most villages. To produce juice with a manual wooden machine, a minimum of four operators were needed (two operating the machine, one feeding the cane into it and the other collecting the products from this machine). For the electric machine, only one person was required to carry out all the operations.

Sugar concentration suitable for this "denge" production is determined by simple tasting. According to the brewers, excessively sweet juice is believed to produce sour "denge." This was also reported by Banwart (1989), and is primarily because *Lactobacillus*, *Leuconostoc* and *Pedicoccus* convert malic acid to lactic acid and carbon dioxide. This fermentation follows the alcoholic fermentation. Likewise, juice not sweet enough produced weak (low-alcohol) "denge," according to the brewers. It is important to standardise sugar concentration prior to addition of the fermenting agents to cause good and standard-quality "denge."

Earlier studies (Greenfield *et al.*, 1985) have shown that, at any particular time, glucose concentration should not exceed 10% (w/v). It was further reported by the

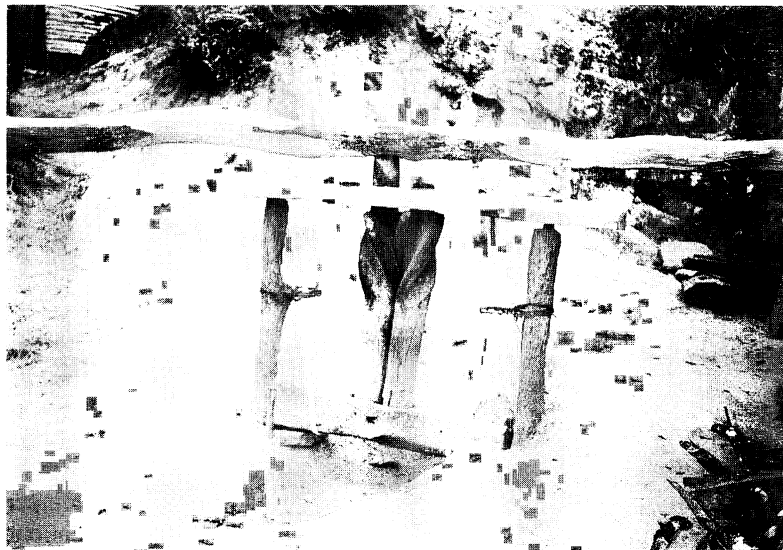


Fig. 6. Local (Wooden) juice extraction machine (Source: Kisangara Village, Mwanga district).

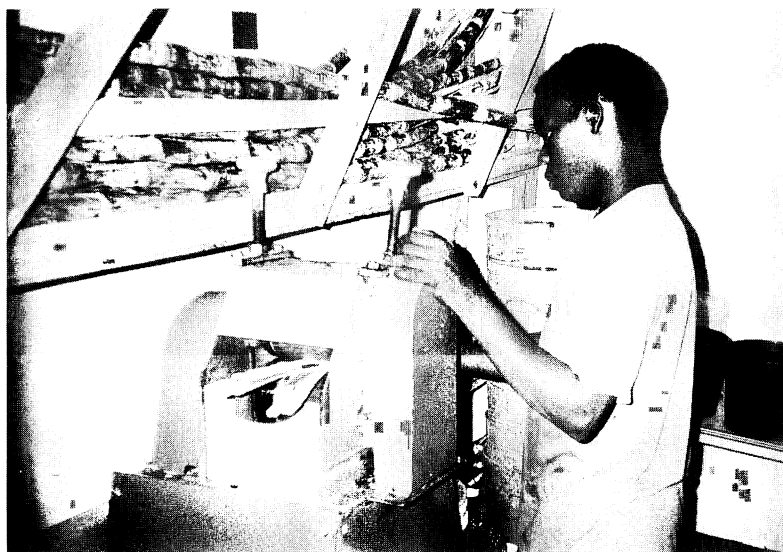


Fig. 7. Modern (metallic) juice extraction machine.

authors that effective ethanol concentration should not greatly exceed 10% (w/v) since it can cause gradual damage to the cell walls of the micro-organisms causing fermentation. This will significantly slow down the fermentation. Rose *et al.* (1970) reported that up to 5% ethanol had the least effect on most common yeasts. Gibbons and Westby (1987) further proved that the highest yeast population resulted in the



shortest fermentation time, the highest ethanol yield, and fermentation efficiency. Deer (1984) reported other factors affecting alcohol production: quantity of fermentable sugars present, conditions of fermentation as to cleanliness and sterility of containers, presence of sufficient nutrients for optimum development of yeast, proper control of temperature.

The conditions encountered during “denge” making in the village lead to spoilage from *Leuconostoc* and heterofermentative lactobacilli, which are inhibited only by over 14 and about 18% alcohol, respectively (Frazier & Westhoff, 1978). Such high levels of alcohol are not attained under normal household “denge” making.

Fermentation process depends on the amount of fermenting agent added, sugar concentration of the juice and the ambient temperature. Usually, fermentation time ranged between 8 and 9 hours, but was longer at lower ambient temperatures, for example, during the cold season. In instances where this fermentation was delayed, households added more sugar, honey or some other fermenting agent to speed up the reaction. The sugar or honey added at this stage was usually heated to a high temperature. This is typical of decoction in the brewing industry, where temperature is elevated to speed up fermentation. The combinations of the above-mentioned parameters in “denge” production warrant investigation.

In “denge” making, the end of fermentation is usually judged by tasting. In other cases, fermentation is terminated when bubbling ceases. Smell is another criterion that is less popular than the previous two for judging the end point of this fermentation process. All three methods seem improbable, especially if a uniform and large-scale production. This highlights the need for developing simple and rapid quality analysis methods.

Fermenting agents prepared from the stem of *Aloe*, generally keep longer than those from *Kigelia*. *Aloe* can be used for 5 years whereas *Kigelia* fermenting agents lose their effect in only a year.

“Denge” does not have a very appealing colour if compared to the commercial beers. To improve this colour and in effect increase its clarity, it is necessary to remove colloidal substances like pectins, gums, proteins and pectosans.

#### V. Quality of “denge” Wine

The quality of “denge” produced in the village has not been investigated. Consumers drink this for the alcohol. Whenever they comment it is good, it refers to the high alcohol content, more than the overall taste.

Amerine *et al.* (1980) reported that about 0.5-1.0% or more of sugar will favour spoilage. When sugar concentration is too high it may inhibit microbial growth since micro-organisms may undergo plasmolysis (Amerine *et al.*, 1980). Too much sugar makes sour-tasting “denge” that is undesirable. This is probably because it encourages proliferation of lactic acid bacteria that can tolerate high levels of sugar, consequently producing a lot of lactic acid.

Fermentation time varied between households, ranging between 8 and 9 hours on average, being shorter in localities where ambient temperature was relatively higher. For the same reason, hot seasons were usually associated with shorter fermentation periods.

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It was reported by "denge" makers that baking was done to remove bitterness and in addition, expose the fibres that play a vital role in fermentation. This study found that the fibre meshwork act as a sponge trapping to a large number of micro-organisms that will inoculate the sugar solution in the "denge" production. This was applicable to the two fermenting agents used in this study. The fermenting agents seem to serve as source of inoculum rather than of bitterness. This is because when the agents are used for five years it lost the bitterness. The function of these agents need to be ascertained. Reports by Leeuweberg (1987) showed the juice of crushed *K. africana* fruit to contain tannins. This could be the major source of bitterness and since these are usually water soluble, supply of inoculum may be the major function of the fermenting agent from *Kigelia*.

In majority of households, "denge" produced was usually left in the fermenting vessel. Otherwise it was kept in plastic containers and bottles with covers or stoppers to avoid conversion of ethanol to acetic acid. The shelf life of "denge" left in the open was hardly 24 hours. This is a big hindrance to its marketing. Consumers and village brewers have tried to prevent oxidation by covering the beverage and removing the fermenting agent early, the former being the most practised option.

Souring of the wine is a common problem in the households. Villagers often add sugar to the sour "denge" and mix this with freshly prepared "denge" to modify the sourness. Selling at a reduced price is another but less common practice.

## VI. Total Soluble Solids

Variation of total soluble solids found over storage time are summarised in Table 2.

These results (Table 2) show that, in the natural state in which the juice is extracted, there are inevitable changes that decrease total soluble solids. Undoubtedly, these affect the sucrose level, and are mostly microbiological as characterised by bubbling (Table 2, footnote) and to some extent biological or biochemical. Dilution of the juice will still reduce the total soluble solids as it does not remove the agents causing the decrease. Dilution accompanied with boiling of the juice show some decrease although not as drastic as observed otherwise, where dilution without boiling was investigated. Concentration of the juice proved to be a good solution to the mentioned changes during storage. The reduction in water activity and destruction of the spoilage organisms during concentration process fully explain these findings.

When inoculated, the total soluble solids decreased (Fig. 8). Untreated sugar seemed to be unaffected during the storage period. This was as expected because

Table 2. Variation of total soluble solids (TSS) (% w/v) with storage.

Treatment	Storage time (h)								
	0	8	36	72	96	120	168	192	216
Raw cane juice	14.4	14.4	14.2 <sup>a</sup>	13.8	13.0	13.0	10.0	9.6	7.8
Diluted (2X) cane juice	7.8	7.2	7.0 <sup>b</sup>	7.0	7.0	6.8	6.0	6.0	4.2
Diluted (2X) and boiled juice	7.8	10.0	10.0	9.6	9.2	8.8	8.6	8.2	7.0
Concentrated juice <sup>c</sup>	14.4	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0

(1) Vigorous bubbling, slime formation and complete colour change evident.

(2) The juice was heated to the concentration of % TSS indicated.

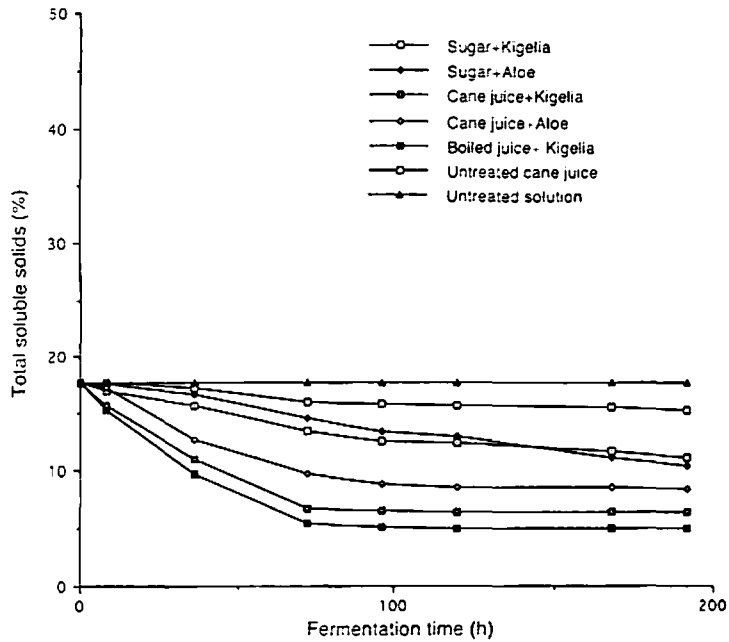


Fig.8. Changes in TSS with fermentaion time.

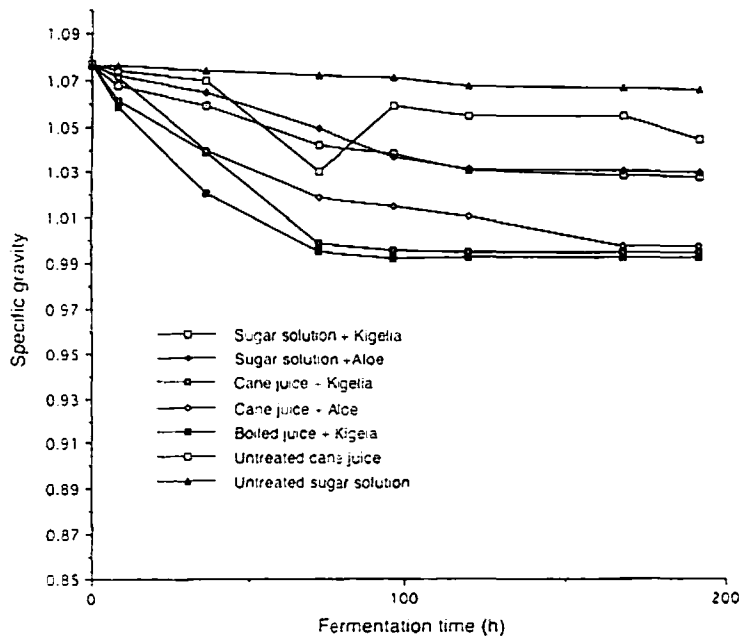


Fig. 9. Changes of specific gravity with fermentation time.

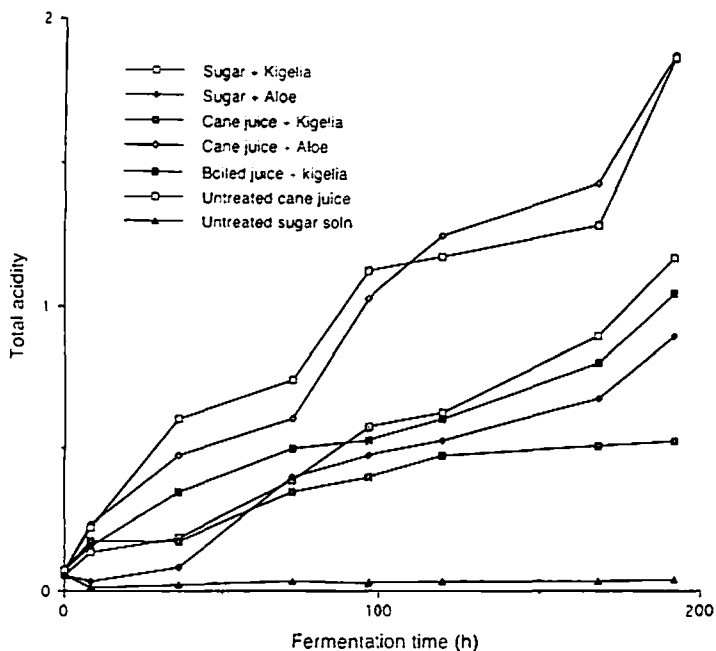


Fig. 10. Changes of total acidity with fermentation time.

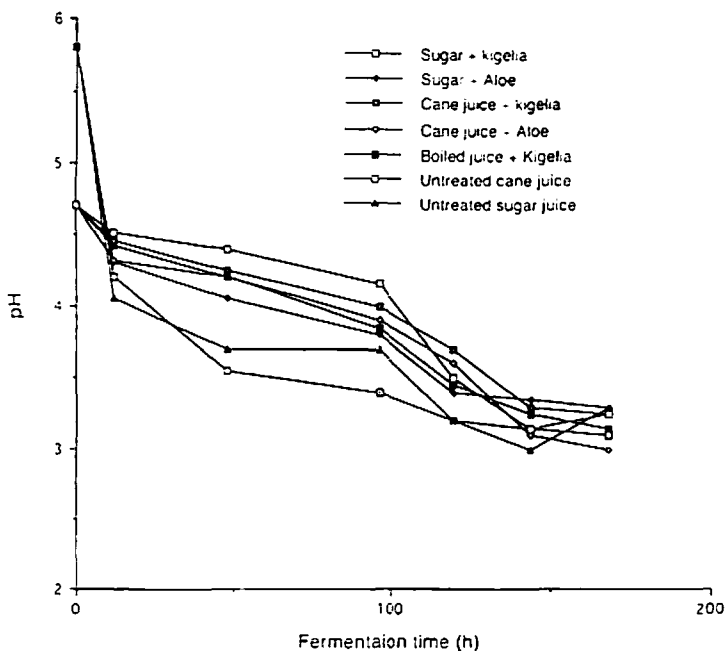


Fig. 11. Changes of pH with fermentation time.

during sugar processing, there is drastic heat treatment that destroys most, if not all contaminating micro-organisms. As far as the fermentation of the juice was concerned, *Kigelia* seemed more efficient than Aloe as indicated by generally low values of percent total solids. *Kigelia* mixed with cane sugar solution was less affected compared to that with juice. This comparison supports that processing of the cane to produce sugar removes some components of significance to growth and multiplication of the micro-organisms carrying out the fermentation.

## VII. Specific Gravity

Specific gravity changes during storage (Fig. 9) proved small in the case of untreated sugar solution. This was expected because, during sugar production, there is maximum destruction of the spoilage micro-organisms and their spore due to the high temperatures encountered during evaporation of the cane juice. The specific gravity of the untreated cane juice without added fermenting agent was also least affected, probably due to limited number of the fermenting micro-organisms. It was interesting to note that all the treatments involving juice and *Kigelia africana* gave the lowest specific gravity values. This indicated disappearance of the sugar to form alcohol or support growth of the microbes during this fermentation. The decrease in specific gravity in the juice or sugar solution containing *Aloe* sp. was less drastic than that noticed in *Kigelia* treatments. The results show *Kigelia* to be more efficient in bringing changes during fermentation. This agrees with the comments gathered from the brewers, that *Kigelia* is the most efficient but difficult component to prepare.

## VIII. Titratable Acidity

Analysis results for titratable acidity measured as percent acetic acid are shown in Fig. 10. Titratable acidity of the untreated sugar solution with no fermenting agent added was very low while that of untreated juice without fermenting agent was quite high and increased as fermentation progressed. This was due to activities of micro-organisms (bacteria and yeasts) from the juice, equipment or handlers. This indicates that microbial activity could originate from the juice even without inoculation from the fermenting agents and partly explains the rapid spoilage of the juice and "denge" reported in the villages. The total acidity increased with fermentation time. Acidity values increased faster in treatments where Aloe plant was involved in the fermentation. There was a general decrease of pH with fermentation time in all the treatments (Fig. 11). More studies are needed to assess the changes under controlled laboratory conditions.

## CONCLUSIONS AND RECOMMENDATIONS

This study highlights the elements of "denge" production and consumption requiring immediate investigation, such as the raw materials, the actual brewing process, and quality of the product. More interaction with the wine makers of this

beverage should lead to gathering of more information on this product. At the moment such interaction is lacking. "Denge" spoils very fast due to aerobic oxidation of the produced ethanol to acetic acid. Some of the plants used to make the fermenting agents for "denge" have been reported to be toxic. Studying these agents seems to be a mandatory measure towards consumer protection. The health problems associated with the consumption also need investigation.

To minimise problems associated with consumption of "denge" several studies are recommended. First would be prolonging the shelf life. Effective bottling will exclude air and consequently ensure minimum conversion of the ethanol produced into acetic acid. Pasteurisation prior to bottling could also help and thus need to be incorporated in such studies.

There is also need to establish the optimum concentration of sugar to produce high alcohol content that can keep during the expected duration of storage. Identification for micro-organisms responsible with this fermentation is required. Use of pure culture of micro-organisms dominant in "denge" production also requires evaluation. This will undoubtedly assist in minimising incorporation of spoilage, pathogenic or toxigenic micro-organisms that affect quality and safety.

Slime production was encountered as a common problem during handling of the raw juice used in "denge" making. Adaptable methods, particularly involving heat treatment, to eradicate this problem call for investigation.

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———— Accepted September 3, 1998.

Authors' Names and Addresses: H.S. LASWAI, *Sokoine University of Agriculture, Department of Food Science & Technology, P. O. B. 3006, Chuo Kikuu, Morogoro, TANZANIA*; A.M.WENDELIN, *Sokoine University of Agriculture, Department of Food Science & Technology, P. O. B. 3006, Chuo Kikuu, Morogoro, TANZANIA*; N. KITABATAKE, *The Research Institute of Food Science, Kyoto University, Uji, Kyoto 611, JAPAN*; T. C. E. MOSHA, *Sokoine University of Agriculture, Department of Food Science & Technology, P.O.B. 3006, Chuo Kikuu, Morogoro, TANZANIA*.