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# Enhance the quality of palmyrah (*Borrasus flabellifer*) jaggery

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**ABSTRACT**

*Palmyrah (borrasusflabellifer) jaggery industry is one of the ancient and large cottage industries in palmyrah society and it is produced by concentrating the inflorescence sap of Palmyrah palm (Sweet Toddy) to a thick consistency. The palmyrah jaggery made in household level has bitter taste due to the presence of excess amount of lime with low purity. During the period of May 2013 to June 2013 four field experiments were carried out to optimize the amount of quick lime (CaO) for a suitable Palmyrah sweet sap collection in the areas of Jaffna district, using Randomized Complete Block design. This experiment was carried out with four different concentrations of quick lime such as* 5.0, 3.0, 2.5 *and* 2.0 *grams of CaO in liter of sap. The quick lime used in this study was produced from sea shells with* 96% *of purity at Palmyrah Research Institute laboratory. Existing palmyrah jaggery available in the market is inferior in its quality as liquefaction and deterioration of color. Through this research attention to be made to eradicate its hydroscopic nature in the existing jaggery to upgrade it. Physicochemical quality parameters of commercially available samples and produced jaggery samples were studied according to Sri Lankan standards for jaggery. Quality of jaggery was enhanced using sweet sap with acceptable lime with higher degree of purity. For suitable jaggery production,* 2.508 ± 0.411 *grams of lime (*96 *% purity) per one liter of sweet sap were optimized and this jaggery was scored high score than jaggery from other field experiments.*

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## INTRODUCTION

Palmyrah (*Borassus flabellifer)* palms are mainly distributed in north and east provinces of Sri lanka and it is known to be a valuable economic plant [1]. There are varieties of palmyrah products available in the local and international market. Palmyrah leaves are used for thatching, mats, hats and different handicrafts, stalks are used to make fence and black timber is used in constructions.

The young, either male or female inflorescences of palmyrah palm produces the fresh sap. The fresh sap is a sweet clear watery liquid and it is a good source of vitamins: riboflavin, vitamin $B_{12}$ vitamin C, thiamine and nicotinic acid and minerals: calcium, iron, zinc, copper and phosphorous [2]. Fresh sap plays a role in the indigenous medicine as anti-diabetic, anti-hyperglycemic and anti-hyperlipidemic agent [3]. This unfermented fresh sap is called as sweet sap or 'pathaneer' [4], it can be consumed freshly or prepare the sap based products. The sweet sap is also allowed to ferment to yield a mild alcoholic beverage which is called "toddy" [5] [6] [7].

The sweet sap based products as jaggery, treacle and sugar candy are made out by concentrating the sweet sap to the suitable consistency in open pans. Palmyrah palm jaggery is the main marketable product and which is more nutritious sap based product, containing 1.04 % protein, 0.19 % fat, 76.86% sucrose, 1.66% glucose, 3.15% total minerals, 0.861 % calcium, 0.052 % phosphorus; also 11.01 mg iron per 100 g and 0.767 mg of copper per 100 g [2]. Jaggery, a sugar rich food product is produced all over the world under different names, such as Gur (India), Desi (Pakistan), Panela (Mexico and South America), Jaggery (Burma and African countries), Jaggery (Sri Lanka),

Htanyet (Myanmar), Panocha (Philippines), Rapadura (Brazil), and Naam Taan Oi (Thailand) [8]. It is consumed directly or used for preparation of sweet confectionery items and ayurvedic/traditional medicines [9].

Fermentation of sweet sap is caused by micro organism and occurs during the period of collection right up to processing. The fermenting organisms are dominated by yeasts, particularly *Saccharomyces cerevisiae* [10]. Traditionally quick lime is used to prevent the fermentation of sweet sap in the preparation of jaggery at the cottage industries in Jaffna peninsula [1, 10]. It is generally obtained from furnacing oysters (mostly sea shell used in Jaffna peninsula) using coconut husk charcoal and the temperature is not up to the optimum level to produce pure lime [REF].Therefore, the quick lime shows a high possible for adulteration by impurities such as ash, sand, unheated sea shells. Another major issue is the local tappers are using excess amount lime which present in sweet toddy. However, there are no studies carried out until now about the composition and purity of quick lime used in local production. Hence this study is to initiate the study on preserve quality for extends the shelf life of palm jaggery and to standardize and improve the techniques of production of jaggery. This leads to increase the local and export market demand for palmyrah jaggery.

## MATERIALS AND METHODS

This research work mainly focuses on the physicochemical properties of jaggery samples and enhance their quality to the international grade via purified and optimized the quick lime

**Determine the physicochemical properties of Sweet sap and Jaggery samples**

Physicochemical properties of commercially available sweet sap and jaggery samples, which are collected from different areas in Jaffna district, were analyzed for this study and the physicochemical properties of the jaggery samples were compared with Sri Lankan Standards for jaggery [11].

**Evaluate the purity of quick lime obtained from the traditional kiln**

The quick lime samples were randomly collected from two different traditional kilns in Anaikoddai area and Pandaitharippu area. These collected quick lime samples were cooled down to the room temperature and packed in a moisture proof container [12]. Moisture free quick lime samples were taken on a clean surface to make cone and it was quartered to get a representative sample of small fragments. $100 - 200$ g of this moisture free quick lime sample fragment was ground well via using the pestle and mortar and it passes through a No. 7 mesh sieve. 0.50 g of sieved quick lime sample was transfer into the 300 mL Erlenmeyer flask containing 20 mL of $CO_2$ free distilled water and plugged the flask immediately. The mixture was swirled and boiled for 2 minutes. Then 150 mL of distilled water and 15 g of sucrose were added to the above mixture. The flask was shaken well for 5 minutes and allowed to stand for 30 – 60 minutes. Then it was titrated with the standard HCl solution by using the phenolphthalein as an indicator and finally the purity of quick lime samples were estimated.

**Prepare the optimum amount of purified quick lime**

Naturally occurring sea shell were randomly collected in the coastal area. Two sets of 10 g of sea shell samples were taken into the crucible plates and kept into the furnace at $750\ ^0$C for 10 minutes and 20 minutes. The above steps were repeated again for the various temperatures such as $850\ ^0$C, $950\ ^0$C and $1000\ ^0$C. Then the purity of the produced lime samples was analyzed and find out the optimum purity of quick lime

**Produce the quality improved sweet sap**

Matured and healthy female palmyah palms were selected near jaggery producing areas of Jaffna peninsula in the period of May to June. The well prepared and healthy inflorescences were identified for the sap collection. The selected inflorescences were tapped in the evening between 5 to 6 p.m to ooze out sweet sap and these were collected in to the well hygienic quick lime applied earthen pots. The known amount of 96 % of purified quick lime was applied into the earthen pots to prevent the fermentation under the previous experience of the local tappers. The different amount of quick lime such as $5\ g/L$, 3 g/L, 2.5 g/L and 2 g/L were applied into the sweet sap collection which are indicate as a field trial such as $T_1$, $T_2$, $T_3$ and $T_4$ respectively

The nylon covering nets were used on pots to avoid the fall/entry of ants, insects and spiders during the collection period of sweet sap. The sixteen hours later, the collected sweet sap samples in earthen pots were quickly transferred into the separate high molecular high density polyethylene (HMHDPE) bottles. Initially, these bottles were washed thoroughly with boiled distilled water, drain out completely and capped immediately to avoid microbial contamination. The sample bottles were placed into a cooler with ice to maintain the temperature below 5 °C and this was immediately transferred to the laboratory in aseptic and sterile condition.

The pH of the sweet sap in each sample bottles was measured directly by using the pH meter (HATH) and Brix was measured by using the hand refractometer. The collected sweet sap samples from various earthen pots in same field trials were pooled together and measured the pH value of this pool sample. Then this pooled sweet sap was transferred into aluminum pan and heated to 120 □C to prepare jaggery. These prepared jaggery samples were packed in high density polyethylene (HDPE) bags under vacuumized condition and jaggery samples were labeled as A, B, C and D which are produced from the field trials T1, T2, T3 and T4 respectively. The produced jaggery samples from various field trials were carried out to select best jaggery samples on the basis of sensory attributes as the colour, odor, appearance, flavor and texture. For this sensory evaluation, the five points hedonic scale was used to select the total acceptability of the samples and it were statistically analyzed using the MINITAB statistical analysis package according to the Friedman nonparametric test at 5 % confidence level of significance [12].

## RESULTS AND DISCUSSION

### The study of quality characteristic of marketable sweet sap

The most significant quality characteristic of the commercially available sweet sap samples, which is obtained from different areas, were analyzed and tabulated in the Table 1. This research study clearly indicates that the marketable available sweet saps have shown higher pH, pale yellow in colour and bitter taste due to the presence of excess amount of quick lime. This unfavorable colour and taste have given unpleasant condition to produce jaggery without deliming treatment. Personal interviews taken from local tappers during our field visits is clearly notified that they haven't any scientifically knowledge about the amount of lime which is adequate to prevent the microbial activities during the collection of sweet sap.

The minimum amount of quick lime addition at higher degree of purity will ensure that the optimum alkaline pH of the sweet toddy.

**Table 1: pH, brix and colour of the commercially available samples**

| Place | pH | Brix | Colour | Taste |
|---|---|---|---|---|
| Pandaiththarippu | 11.20 | 11.5 | White | Bitter |
| Pandaiththarippu | 11.14 | 11.0 | White | Bitter |
| Chavakacheri | 11.71 | 13.5 | Pale yellow | Bitter |
| Chavakacheri | 11.70 | 12.5 | White | Bitter |
| Atchuveli | 11.20 | 11.4 | White | Bitter |
| Atchuveli | 11.62 | 12.5 | Pale yellow | Bitter |
| Atchuveli | 11.23 | 11.0 | White | Bitter |
| Kondavil | 11.68 | 13.2 | Pale yellow | Bitter |
| Kondavil | 11.55 | 12.6 | Pale yellow | Bitter |
| Allarai | 11.12 | 12.4 | White | Bitter |
| Allarai | 11.59 | 13.0 | Pale yellow | Bitter |

### Study the chemical constituents of marketable Jaggery

The moisture content, total ash, acid soluble ash, matter insoluble in water and reducing sugars of the marketable jaggery samples obey the limits of specification for jaggery according to the Sri Lankan standards but sugars and non reducing sugar content is exceed the SLS standard level [12]. The most significant chemical constituents for the jaggery samples are listed down in table 2.

**Table 2: Chemical constituents of the market available Jaggery**

| Sample No | Moisture content percent by mass (W/W) | Total ash percent by mass (W/W) | Acid insoluble ash percent by mass (W/W) | Matter insoluble in water percent by mass (W/W) | Reducing sugars percent by mass (W/W) | Sugars, non - reducing sugars percent by mass (W/W) |
|---|---|---|---|---|---|---|
| 1 | 6.78 % | 1.83 % | 0.11 % | 1.23 % | 6.10 % | 76.80 % |
| 2 | 3.39 % | 1.45 % | 0.12 % | 1.65 % | 2.32 % | 91.09 % |
| 3 | 6.79 % | 2.65 % | 0.20 % | 1.43 % | 2.16 % | 88.04 % |
| 4 | 7.48 % | 2.62 % | 0.30 % | 1.65 % | 2.11 % | 81.20 % |
| 5 | 7.07 % | 2.45 % | 0.13 % | 1.65 % | 5.79 % | 82.65 % |
| 6 | 7.73 % | 1.80 % | 0.11 % | 1.23 % | 2.25 % | 85.61 % |
| SLS | 10 % (max) | 3.5 % (max) | 0.5% (max) | 2 % (max) | 13% (max) | 70 % (max) |

The moisture in the products exceeded the SLS limits at ambient temperature before their expiry period, is tabulated in table 3. Therefore, jaggery samples start to melt before the expired.

**Table 3: The moisture content in the commercially available jaggery samples**

| Sample No | Moisture content percent by mass in 1st day | Moisture content percent by mass after 3rd month |
|---|---|---|
| 1 | 7.72 | 23.16 |
| 2 | 8.43 | 21.82 |
| 3 | 8.19 | 22.89 |

**Study the purity of commercially available quick lime**

This research study clearly point out that the commercially available quick lime which is collected from Anaikoddai kilns shown slightly higher purity rather than the Pandaitharippu kilns. However these two Type equation here.kilns are not produce high purified quick lime, which is, tabulated in table 4. This impurity arises from the traditional kiln due to the following drawbacks such as (a) the kiln totally opens to environment and using coconut husk to heat sea shells. The important reaction occurs in the lime producing kiln take place at the optimum temperature (900 $^0$C) which is the calcining of limestone.

$$CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$$

However, this heating process cannot be reached the actual temperature of above 900 $^0$C [14]. (b) The sea shells are packed in several layers and between these layers coconut husk are spreaded into the traditional kiln. Therefore, there are the possibilities for adulteration by impurities as soil and coal present in quick lime. According to the results from the research work and the above drawbacks, traditional kiln should be modified in the future to produce a highly purified quick lime.

**Table 4: The purity of commercially available quick lime**

| Place | Purity of lime expressed as CaO (%) |
|---|---|
| Anaikoddai | 59.99 ± 0.97 |
| Pandaitharippu | 42.34 ± 0.74 |

**Study the purity of quick lime in the laboratory scale**

A various yield percentage of quick lime was produced as a function of temperature and time. In this study, 800 $^0$C is not enough to produce the lime above 90 % of purity. Other temperature treatments are selected to optimize the time. We can get lime with 96 % of purity in above the 800 $^0$C. Even the purity of lime is increasing with increased the time period and the temperature. Finally, 850 $^0$C for 30 minutes treatment was selected as a best consumable method to produce lime with minimal amount of energy required.

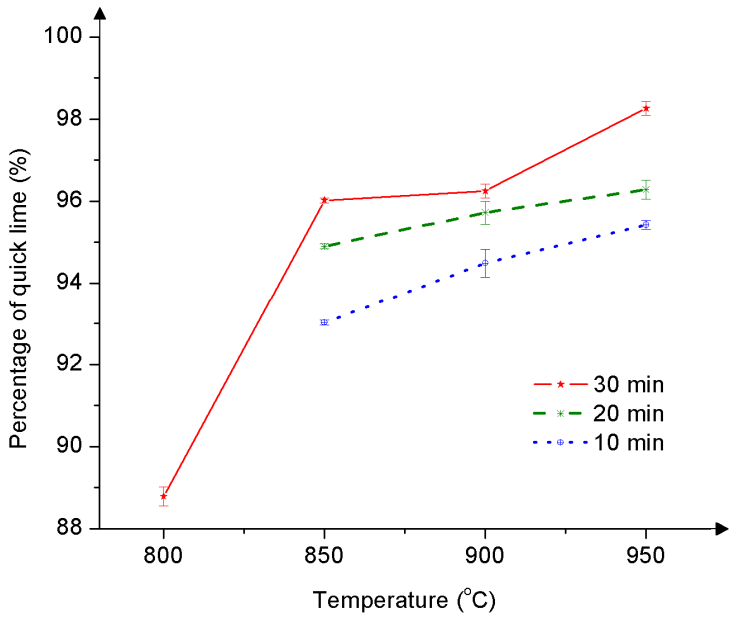


**Figure 1: The percentage of quick lime as a function of the various temperature for the treatment of 30 minutes (— line), 20 minutes (- - - - line) and 10 minutes (..... line).**

**Collection of sweet sap**

Different field visits were carry out to optimize the lime for the processing of palm jaggery and all the summarized results were recorded in the table 10. In field visit 1 ($T_1$), field visit 2 ($T_2$), field visit 3 ($T_3$) and field visit 4 ($T_4$) amount of applied quick lime were $4.668 \pm 0.847$ g/L, $3.188 \pm 0.242$ g/L, $2.508 \pm 0.411$ g/L and $2.051 \pm 0.833$ g/L and pH of them were 11.51, 10.62, 9.43 and 8.23 respectively. According to Sri Lankan Standard [1] fresh jaggery samples from $T_1$, $T_2$ and $T_3$) field visits at the time of packaging moisture content of all was below 10 %. Sweet sap samples with pH between 7 and 8 quickly changed into acidic medium with time and this indicates the microbial activity is present considerably. Jaggery from field visits $T_4$ shows melting property and moisture content was below12.5 %. It was identified that fermented sweet sap also course melting of jaggery. Therefore pH of sweet sap needs to be maintained above pH 9 in large scale application. For the suitable jaggery production without deliming step $2.508 \pm 0.411$ g of lime (96 % purity) per one liter of sweet sap was optimized.

**Table 10: Summary of all field visits**

| Filed visit | Name of the inflorescence | Amount of quick lime (g/L) | pH of Pooled sap | Brix of poled sap |
|---|---|---|---|---|
| $T_1$ | $F_1$, $F_2$, $F_4$ & $F_5$ | 4.668 ± 0.847 | 11.51 | 12.8 |
| $T_2$ | $F_6$, $F_7$, $F_8$ & $F_9$ | 3.188 ± 0.242 | 10.62 | 11.72 |
| $T_3$ | $F_{11}$, $F_{12}$, $F_{13}$, $F_{14}$ & $F_{15}$ | 2.508 ± 0.411 | 9.43 | 11.63 |
| $T_4$ | $F_{16}$, $F_{17}$, $F_{18}$, $F_{19}$, $F_{20}$, $F_{21}$, $F_{22}$ & $F_{23}$ | 2.051 ± 0.833 | 8.23 | 11.00 |

**Sensory evaluation of produced jaggery**

Sensory data obtained through the five point hedonic evaluating test, revealed that there were significance difference in colour ($p = 0.012$), appearance ($p = 0.003$) and texture ($p = 0.001$) characteristic among the jaggery samples produced in the laboratory. However there were no significant difference in flavour ($p = 0.296$) and mouth feel ($p = 0.145$) among the samples. The sample C gained the highest rank for the colour, appearance, and texture. Therefore the sample C was selected as the best sample.

**Table 11: sensory attributes of the jaggery**

| Sensory attributes | P value | Sum of the rank | | | | Best sample |
|---|---|---|---|---|---|---|
| | | A | B | C | D | |
| Colour | 0.012 | 19.5 | 27.5 | 29.5 | 13.5 | C |
| Appearance | 0.003 | 17.5 | 29.0 | 30.0 | 13.5 | C |
| Texture | 0.001 | 17.0 | 28.5 | 31.5 | 13.0 | C |
| Flavour | 0.296 | 18.0 | 27.5 | 24.5 | 20.0 | B |
| Mouth feel | 0.145 | 15.0 | 24.0 | 27.0 | 24.0 | B |

**Evaluation of moisture content of prepared Jaggery samples**

Moisture content of prepared jaggery samples were determined in different time periods as in first day, after first month and after sixth month. Jaggery from fourth field trial melted before one month and this indicates even the pH 8 is suitable to produce jaggery fermented sap causes the melting of jaggery easily. Jaggery produced from other field trials can be stored for six months.

**Table 12: Moisture content of jaggery with average of triplicate readings after 6 months**

| Field trials | Moisture content percent by mass in 1st day | Moisture content percent by mass after 1st month | Moisture content percent by mass after 6th month |
|---|---|---|---|
| $T_1$ | 3.52 | 3.72 | 8.69 |
| $T_2$ | 3.98 | 4.01 | 8.94 |
| $T_3$ | 4.12 | 4.87 | 9.45 |
| $T_4$ | 4.43 | 25.65 | - |

## CONCLUSION

Palmyrah jaggery is one of the most popular sweeteners in north and east provinces of Sri Lanka. The color of the sweet sap was improved with using the proper amounts of applied lime per liter.

Sweet sap should be maintain at pH 9 by using a purified quick lime to stop the fermentation and it can be useful to get quality improved jaggery as high consumer acceptance in the market level. At this optimum pH range jaggery can be produced without deliming step from fresh, unfermented and filtered sweet sap of palmyrah palm.

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