Effect of Furnacing Time Periods and Temperature on the Purity Quick Lime for the Production of Palmyrah Jaggary

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Abstract
Quick lime is commonly used additive in Sri Lanka during the period of Palmyrah (*Borassus flabellifer*) sweet sap collection to delay sap fermentation by natural yeast and bacteria. There are several Palmyrah sweet sap based products such as jaggery, treacle, sugar candy and sugar produced in northern Sri Lanka which shows poor keeping qualities and large variation in physicochemical characteristics among batches. Quality of the above products mainly connects with collection of raw material. Local tappers follow poor quality control practices such as applying excess amount of quick lime with low purity that is adulterated by impurities (sand and ash). In Jaffna two traditional kilns present in Pandaiththrippu and Anaikkoddai produce quick lime from sea shells using coconut husk charcoal. Purity of quick lime expressed as CaO (g/100g) produced from Anaikoddai kiln was 59.99±0.97 and Pandaitharippu kiln was 42.34±0.74. Quick lime produced from both kilns were not in suitable condition to be used during processing of Palmyrah sweet sap for the production of standardized Palmyrah sweet sap based products. Temperature (levels 750 ^{0}C, 850 ^{0}C, 950 ^{0}C and 1000 ^{0}C) and time period (10, 20 and 30 minutes) combinations of treatments were carried out to produce high purity quick lime through furnacing of sea shells. The experiment was arranged in two factor factorial design. Purity of quick lime obtained was statistically analyzed using SAS. Significant differences were observed among all selected temperatures and time periods. Significantly highest value for quick lime purity was obtained in 1000 ^{0}C and 30 minutes. Application of the treatments 1000 ^{0}C for 20 minutes, 1000 ^{0}C for 30 minutes, 950 ^{0}C for 30 minutes and 850 ^{0}C for 30 minutes were produced significantly same and higher purity of quick lime compared to other of treatments. According to high energy consumption 850 ^{0}C for 30 minutes treatment was selected to produce quick lime with 96.02±0.06 % of purity.

Keywords: Kiln, Palmyrah (*Borrassus flabbellifer*), Quick lime, Sweet sap

Introduction

Matured male and female inflorescences of Palmyrah palms are tapped to ooze sweet sap. In Sri Lanka earthen pots with inside application of quick lime are used to collect sweet sap (Theivendirarajah, 2008). Barh and Mazumdar (2008) reported that Palmyrah sap is a good source of vitamins such as riboflavin, vitamin B_{12}, vitamin C, thiamine and nicotinic acid and minerals such as Calcium, Iron, Zinc, Copper and Phosphorous. Rao *et al.* (2009) stated that the pH of fresh Palmyrah sweet sap is 6.8 and total sugar content is 10.93. Hence sweet sap can easily undergo alcoholic fermentation by natural yeast and other microorganisms in the environment. Application of quick lime maintains the sweet sap in basic medium (pH ≥ 8.5) which is susceptible to microbial activity during the period of sweet sap collection.

In Jaffna there are two traditional kilns present in Pandaiththrippu and Anaikkoddai area producing quick lime from sea shells. These kilns are simply made by brick stones on ground and totally open to environment. Coconut husk and fire wood are used to heat sea shells. The above firing materials are spread into several layers between sea shells. The important reaction occurs in lime producing kiln take place at the optimum temperature (900^{0}C) which is the calcining of limestone (Atkins *et al.*, 2010). In traditional kilns during processing of quick lime local firing materials are produced inadequate heat and temperature is not reached to 900 ^{0}C inside of the kiln. Hence sea shells were partially converted into quick lime. Mostly it is continued for one day and next day after it is cooled to environmental condition produced quick lime was packed into polythene bags to send to sweet sap based industries without quality checking.

Purity of quick lime from traditional kilns was unknown. Hence it should be studied first to enhance the quality of sweet sap processing. The main objective of this research study is to find out suitable temperature and time period combination to produce quick lime with optimum purity. Application of quick lime at higher degree of purity and minimum amount of it will ensure quality control of sweet sap.

Materials and Methods

Collection of lime samples

Quick lime samples were collected from traditional lime producing kilns build up in two areas of Jaffna namely as Anaikoddai and

Pandaitharippu. The kilns were allowed to cool to environmental condition after processing is finished. Produced quick lime samples were randomly collected in different parts of kilns into moisture proof bags and these were transferred to Palmyrah Research Institute laboratory. Collected quicklime was 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 was ground by using mortar and pestle and it was passed through a No.7 mesh sieve to sieve the sample.

Analysis of the purity of quick lime

Sample of quick lime (0.50 g) was weighed accurately and it was applied into a 300 ml Erlenmeyer flask containing 20 ml of CO_2 free distilled water. Sample containing flask was heated to boiling for 2 minutes. Distilled water (150 ml) and 15 g of sucrose were added. The flask was capped and it was mixed by shaking at intervals for 5 minutes. It was allowed to stand for 30 minutes to 1 hour. After washing the sides of the flask with distilled water, the content was titrated against standard HCl solution (0.1 M) with using phenolphthalein as an indicator. About 90% of the estimated amount of acid was added before shaking the flask and then complete titration, with the final acid being fed slowly until the pink colour disappears.

Optimization of conditions for quick lime preparation

Natural sea shells were collected by using convenience sampling method in coastal area near to Anaikoddai and Pandaitharippu. Laboratory muffle furnace (Manufacture: Hobersal , Model : JD230 "PAD" and temperature range: 100 °C - 1200 °C) was used to produce quick lime. Temperature and time period (two factors) were taken as variables. Hence experiment was designed in two factor factorial complete randomized design. Four different temperatures (750°C, 850 °C, 950 °C and 1000 °C) and three different time periods (10 minutes, 20 minutes and 30 minutes) were selected to optimize processing conditions (temperature and time period) to produce high purity quick lime.

Collected sea shell samples were taken into the crucibles and kept into furnace and produced quick lime samples were cooled to room temperature and immediately packed into air tight glass containers to analyze the purity of quick lime. The study was performed with three replicates for 12 treatments.

Statistical analysis

All results (purity of quick lime) were analyzed in SAS 9.1 software and the mean separation was done by least significant difference (LSD) at p=0.05. Analyzed entire data obtained during the experiment was expressed as means ± standard deviation.

Results and Discussion

Purity of quick lime produced from traditional kilns

Analysis of results revealed that the purity of quick lime expressed as CaO (g/100g) produced from Anaikoddai kiln was 59.99±0.97 and Pandaitharippu kiln was 42.34±0.74. It shows high significant difference between produced quick lime samples from two traditional kilns and purity also very low in both kilns. Therefore it is essential to increase the purity factor of producing quick lime in order to maintain quality control during processing of Palmyrah sweet sap which is essential to produce standardized Palmyrah sap based products.

Purity of prepared quick lime

Significant differences observed among four different temperatures and among three different time periods. According to the results, significantly highest lime purity was obtained in 1000 °C for 30 minutes. Since results revealed that temperature and time period are the factors determining the purity of quick lime; results should be statistically analyzed for combination of those two factors. It is better method to get economically viable temperature and time period combination for industrial application. All combination of temperature and time period treatments were completely randomized to perform statistical analysis and obtained mean and significant values were indicated in Table 1.

Among those 12 treatments there were no significant difference were observed among

Table 1: Effect of applied temperature and time period combination on purity of quick lime

Temperature	10 minutes	20 minutes	30 minutes
750 °C	86.58±0.11^{i}	87.92±0.34^{h}	88.78±0.23^{g}
850 °C	93.02±0.06^{f}	94.90±0.06^{d}	96.02±0.06^{ab}
950 °C	94.49±0.34^{e}	95.72±0.28^{bc}	96.25±0.17^{a}
1000 °C	95.42±0.11^{c}	96.28±0.23^{a}	96.32±0.11^{a}

Values are presented as mean ± Standard Deviation (for standards 3 replicates) Values in the above table with same superscript letters are not significantly different (P<0.05)

1000 ^{0}C for 20 minutes, 1000 ^{0}C for 30 minutes, 950 ^{0}C for 30 minutes and 850 ^{0}C for 30 minutes. Those four treatments also got significantly higher value for quick lime purity rather than that of other 8 treatments. Hence 850 ^{0}C for 30 minutes could be selected as best temperature and time period combination when compared to 1000 ^{0}C for 20 minutes, 1000 ^{0}C for 30 minutes, and 950 ^{0}C for 30 minutes.

Furnacing of sea shells at 850 ^{0}C for 30 minutes yields quick lime (≤96 %) and this purified known amount of quick lime was applied to sweet sap to select the optimum quantity sweet sap for the production of best quality jaggery. For suitable jaggery production without deliming step, 2.5 grams of lime (96 % purity) per one liter of sweet sap (pH=9) was found to be the best as determined by sensory evaluation (Mary *et al.*,2014). Following quality control measures during sweet sap collection leads to enhance the marketability of Palmyrah sweet sap based products locally and internationally.

Conclusion

Furnacing of sea shells at 850 ^{0}C for 30 minutes yields quick lime (≤96 %) that could use to produce the best quality jaggery.

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