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Storage study of jaggery obtain from cooling machine

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Abstract
Jaggery, a traditional non-centrifugal sugar product made from sugarcane or palm sap, is a staple sweetener in many parts of the world. However, its storage presents a challenge due to its susceptibility to moisture absorption, and crystallization. The solid jaggery obtained from sugarcane juice were kept at room temperature (25-28 °C) for determining their better shelf life. Moisture content, colour, pH, reducing sugars, and non-reducing sugars were estimated for shelf life study. Results revealed that solid jaggery obtained from jaggery cooling machine with best operating parameters are kept for 90 days' storage study having a good shelf life and quality.

Keywords: Jaggery, striking temperature, different types of jaggery: moulds, storage, experiment

Introduction
Jaggery is also known as gul in Maharashtra. It is a natural, traditional sweetener, prepared by concentrating the sugarcane juice. Jaggery is a traditional unrefined non centrifugal sugar mostly consumed in Asia, Africa, Latin America and the Caribbean. Because of its minerals and vitamins contents as present in sugarcane juice, it is known as healthiest sugar in the world. Generally, its colour varies from golden yellow to golden brown. Mineral like magnesium present in jaggery strengthens human nervous system and helps to relax body muscles, gives relief from fatigue and takes care of blood vessels. It also acts as an antioxidant along with selenium, having property to scavenge free radicals from our body. Jaggery contains potassium and low amount of sodium which helps to maintain the acid balance in the body cells, and also combats acids and acetone and controls body blood pressure. Jaggery is called as rich source iron which helps to prevent anemia. Because of its anti-allergic properties, it helps to relief tension and takes care of asthma (Kumar *et al*., 2013, Singh *et al*., 2011) [6, 9]. The quality and price of jaggery is depends upon its external features like color and texture. A best quality jaggery is judged by its features like golden yellow in color, hard in texture, crystalline structure, and its unique sweet taste, less in impurities like molasses and some crystals and low in moisture. For marketing point of view grading of jaggery is done as grade I jaggery and grade II jaggery based on its physical quality parameters like colour and texture, and chemical quality parameters like sucrose content, reducing sugar, moisture, water insoluble material, etc (Kumar *et al*., 2013) [5].
Generally, in market jaggery is available in three forms such as solid jaggery, liquid jaggery and granular jaggery. In India, solid jaggery is prepared from sugar cane juice (*S. officinarum*), approximately 80 per cent of jaggery is prepared in the form of solid structure known as solid jaggery and remaining 20 per cent includes liquid jaggery and granular powder jaggery (Vengaiah *et al*., 2013) [11]. Liquid jaggery is also called as 'Kakawi' in some regions of Maharashtra (Nath *et al*., 2015) [7]. During concentrating the sugarcane juice, when solid content reaches around 90-92° Brix with a corresponding temperature of 118- 120 °C, the intermediate product is collected which is popularly known as solid jaggery. The temperature and concentration is depending upon different varieties of cane and agro-climatic zones (environmental conditions in which cane grows). Stirring of hot jaggery in cooling pit is one of the critical operations in jaggery processing which decides quality of jaggery in terms of jaggery granularity and colour. It is very labor intensive and traditionally about by 4 to 5 labors are engaged in carrying out this operation using long handled scrapper. Cooling pit is constructed below ground level and labors are workers. No hygiene is maintained around the pit. Very short period is available after stirring operation to fill the jaggery into moulds.

As temperature of hot jaggery goes down, it becomes dry and difficult to fill into moulds. Dried jaggery if filled into moulds, then cracks get developed and jaggery loses surface finish. Such jaggery is sold at much lower prices than regular finished one. Also filling of jaggery in small moulds, modak shape, bar /cube shape needs to be filled before jaggery loses its flowability. Keeping this point of view jaggery cooling machine were introduced for hot molten mass of jaggery is allowed to cool in the machine for 25-30 minutes with continuous stirring operation.

Materials and Methods

In the present experiment jaggery prepared from jaggery cooling machine were kept for storage study is done. Solid jaggery from sugar cane juice Samples are kept at room temperature (25-28 °C) with five replications. The stored jaggery samples were analyzed for parameters like moisture content, reducing sugar, non- reducing sugar, pH, colour.

Analysis of quality parameters

The moisture content of the solid jaggery samples and granular jaggery was determined by using the method of AOAC (2005). A 10 g of the sample was weighed and placed into a pre–weighed crucible and then dried at 70 ± 2 °C till the dryness occurs. Reducing sugars and non-reducing sugars content of all samples were determined by the method of Lane and Eynon modified by Ranganna (2005). The pH was determined by using digital pH meter (AOAC, 2005). By using a spectrometer/spectrophotometer method colour of samples will be dissolved in distilled water (10%) and filtered through Whatman No.2 filter paper. The filtrate will be used for colour measurement. The absorption value of the jaggery sample will be recorded at 540 nm (Chikkappaiah *et al*., 2017) [3].

Statistical analysis

The data was statistically analyzed using FCRD (Factorial Complete Randomized Design). The replications of storage study were carried out in triplicate. The analysis of variance and least significance difference or critical differences were used to determine the significance of main effects at 1 and 5 per cent level of significance (Sundaraj *et al.*, 1972) [10].

Result and Discussion

Fresh jaggery obtained from sugarcane juice with different operating machine parameters was analyzed for its physico-chemical properties of fresh jageery. During estimation the values for moisture content, pH, reducing and non-reducing sugars, colour are calculated for jaggery (Table 1).

Effect of stirring speed and time on Physico-chemical properties of fresh jaggery

Data representing effect of stirring speed and time on physical and chemical properties of jaggery prepared is given in Table 1. It was observed from data that, moisture content variation ranged between 12.57 to 9.53 percent. It might be due to higher temp 105.73°C at the time of mould filling evident that insufficient stirring and cooling. Sufficient amount of stirring and cooling is essential for removal of moisture and helping to for crystals along with imparting colour. Hence it is cleared that, increasing stirring speed (18, 20, 22 rpm) and stirring time (20, 25, 30 min) jaggery moulds set properly with less moisture content indicating proper cooling and crystallization.

The effect of operating speed, time and batch on moisture content R_{22} T_{30} B_{75} was significantly higher than other treatment products at par with R_{22} T_{20} B_{75}.

Reducing sugar was directly proportional to time and temperature of stirring. It has effect on reducing and non-reducing sugars. The maximum percent of reducing sugar was found due to a higher temperature as kinetic energy of hot jaggery molecules increases which leads to faster molecular movement and collision. The breakdown of larger carbohydrate molecules results rise of reducing sugar. Also at lower temperature the kinetic energy of molecules decreases which leads slower molecular movement and collision due to this less reducing sugar were observed. The effect of operating speed, time and batch on reducing sugars R_{22} T_{30} B_{75} was significantly higher than other treatment products.

The effect of operating speed, time and batch on non-reducing sugars R_{22} T_{30} B_{75} was significantly higher than other treatment products at par with R_{22} T_{20} B_{75} and R_{22} T_{25} B_{75}. In non-reducing sugar at higher temperature (105.73 °C) non-reducing sugars are more likely to undergo hydrolysis which breaks them into their constituent monosaccharides including reducing sugars at higher temperature appears lower due to the ongoing conversion into reducing sugar.

It was observed the variation of pH between 6.11 to 6.77 So, there is minimal effect on physico-chemical properties. There is effect on colour of jaggery. The color of jaggery influenced by pH it could be affect the maillard reaction and Caramelization which are responsible for the browning and colour development in food like jaggery. We required higher efficiency of machine we consider the observations of 75 Kg batch. Finalized treatment (22 rpm, 30 min) for jaggery mould preparation and the sample from that treatment selected for further three-month storage study.

Moisture content and pH

The results revealed that moisture content of solid jaggery stored at room temperature significantly decreased during the 90 days of storage period (April to June) due to the increase in temperature and decrease in relative humidity so decrease in rate of moisture migration during period of storage. The changes in moisture content S_4 (90 days) was significantly higher than all storage period at par with S_3 (60 days). Also results revealed that there is significant decrease in pH in of jaggery. Stored at room temperature as storage time increases. It may be because of change in chemical composition in the jaggery during storage. All results are tabulated in Table 2.

Reducing sugar and non-reducing sugar

The results revealed that there was significant effect of storage conditions and storage period on reducing sugar of stored jaggery. The maximum value of reducing sugar is observed as 9.86 % after 90 days' storage. This is because conversion of sucrose into glucose and fructose by means of hydrolysis is the reason for increase in reducing sugar [Chand *et al.*, (2011), Guerra and Mujica (2009) and Mandal *et al.*, (2006)] [2, 4, 6]. There was decrease in the non-reducing contents at room temperature. It is worthwhile to note that the decrease in non-reducing sugars or increase in reducing sugars is more or less because of changes of moisture. [Chand *et al.* (2011), Sankhla *et al.* (2013), Guerra and Mujca (2009) and Mandal *et al.* (2006)] [2, 8, 4, 6].

Colour

The results revealed that there was significant effect of storage conditions and storage period on colour of stored jaggery (Table 3). The jaggery stored at room temperature showed significant decrease in colour from 0.182 to 0.153 due to oxidation during 90 days of storage (April to June). The changes in colour depend upon moisture content and enzymatic reactions.

Table 1: Effect of stirring speed and time on physico-chemical properties of fresh jaggery before storage

Batch	RPM	Filling time (min)	Moisture content (%, db)	Reducing sugars (%)	Non-reducing sugars (%)	pH	Colour
50 Kg	18	20	11.77	15.31	68.58	6.42	0.32
		25	11.49	13.22	70.44	6.34	0.28
		30	11.26	12.36	72.34	6.44	0.27
	20	20	12.40	14.58	67.23	6.22	0.34
		25	11.47	13.22	68.57	6.39	0.31
		30	11.41	12.34	70.67	6.41	0.31
	22	20	12.03	13.35	69.57	6.35	0.25
		25	12.26	11.67	73.87	6.18	0.22
		30	10.98	8.76	76.52	6.55	0.19
75 Kg	18	20	12.57	15.72	65.89	6.31	0.26
		25	12.22	14.23	67.35	6.11	0.21
		30	12.89	13.47	68.49	6.26	0.18
	20	20	12.01	14.98	65.19	6.32	0.18
		25	11.65	13.93	66.07	6.24	0.17
		30	11.38	12.31	69.45	6.4	0.15
	22	20	11.48	14.12	72.04	6.77	0.20
		25	10.33	12.11	74.83	6.18	0.17
		30	9.53	8.85	76.40	6.32	0.16
speed × time × Batch		SEm(±)	0.332462	0.435358	0.586681	0.095115	0.020098
		CD at 5%	1.953554	1.248677	1.682694	NS	NS

Table 2: Effect of storage period on moisture content and pH of jaggery moulds

Storage (days)	Moisture content (%)	pH
0	10.45	6.35
30	9.23	6.27
60	8.27	6.16
90	7.69	6.04
SEm	0.1989	0.0325
CD 5%	0.5965	0.09

Table 3: Effect of storage period on reducing sugar and non-reducing sugar of jaggery moulds

Storage (days)	Reducing Sugar	Non-Reducing Sugar	Colour (absorption value)
0	8.85	75.51	0.182
30	9.18	74.36	0.1728
60	9.32	72.51	0.1634
90	9.86	71.01	0.1534
SEm	0.19	1.4119	0.0133
CD 5%	0.59	4.23	0.0399

Conclusion

It can be concluded from the facts stated that in this research that solid jaggery can be stored at room temperature for three months. The quality and colour are the important properties which determines the consumer acceptability towards jaggery. Also hygiene's are maintained and less labour requirement during cooling of hot jaggery. This study can be helpful for the farmers as well as processing plant of jaggery for keeping jaggery quality suitable for consumption and increasing its market value.

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