Jaggery quality effected by hilly climatic conditions

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Investigations were carried out for storage behaviour of jaggery samples, stored in polythene bags, IISR bins and hanging baskets under hilly climatic conditions of Uttarakhand. Samples were stored for a period of five months during which changes in product parameters such as moisture content, sucrose, reducing sugar and colour were determined at an interval of 30 days. The study revealed that the quality of jaggery was affected significantly by both containers as well as ambient conditions. All the quality attributes like reducing sugar, sugar and colour were affected by the storage conditions. Jaggery stored in IISR bins retained its quality throughout the study, whereas jaggery samples kept in hanging baskets and polythene bags deteriorated at faster rates. The moisture content jaggery samples increased from an initial value of 11.02-24.32% in open storage, while it only increased to 14.89% in bins and 15.84% in case of polythene bags. Similarly the change in percentage of sucrose, reducing sugar and colour was observed less for the samples kept in storage bins and polythene bags than for the samples kept in open storage. Overall, IISR bin preserved the quality better than the open and polythene bag storage.

Keywords: Jaggery, Moisture content, storage behavior, Gur

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Jaggery is directly consumed by human and used in animal feed mixtures. Jaggery is a natural sweetener made by the concentration of sugarcane juice prepared without any use of chemicals. It contains the natural goodness of minerals and vitamins inherently present in sugarcane juice and this crowns it as one of the most wholesome and healthy sugars in the world. Jaggery contains 28 gm/kg of mineral salts, as against only 300 mg/kg is found in refined sugar. It is very useful in health problems like dry cough, cough with sputum, indigestion, constipation, etc. It purifies the blood, prevents rheumatic afflictions and disorders of bile and possesses nutritive properties of high order. Being a completely natural product its keeping quality is very poor and needs very specific conditions. For storage, the optimization of physical factors of humidity, temperature, etc. have to be regulated to maintain the quality of jaggery. The magnitude of storage losses and importance of proper storage systems have drawn the attention of researchers for the last several decades leading to development of improved technologies for storage of Jaggery. However, strong role of climatological parameters in preserving jaggery during storage needs to be carried out under various climatological conditions. Very little work has been done on deterioration behaviour of jaggery (especially in Tarai region and hilly regions), therefore, it is necessary that the storage behaviour of this commodity should be studied in detail with a view to develop appropriate conditions for their proper storage. In view of this, the present study has been conducted to study the storage behaviour of jaggery in cold hilly climate of Uttarakhand.

Study

Traditional methods of jaggery storage prevalent in western and eastern regions like open storage, matka, gunny bags etc. These methods don’t work in Tarai regions because climatic conditions are not favourable for keeping quality of jaggery as there is very high humidity in these areas. During monsoon period, due to high humidity range, jaggery samples get infected with microbial activity and thus keeping quality of jaggery goes down. Jaggery samples could be stored in cold storage but sometimes it is difficult to store the samples for small scale farmers as cost involved is the main constraint for that. Also the energy consumption is very

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high. Jaggery from cold storage is used in off-season at high cost\(^5\). Keeping in view the above facts, a jaggery drying-cum storage bin was fabricated at Lucknow centre as per the design of IISR, Lucknow.

**Drying cum storage bin**

It is a galvanized iron sheet drum having a full size lid with a chimney in its centre. There are 4 holes at the bottom side of the drum for aeration inside it. A perforated sheet or wire mesh is placed at the bottom of the drum and jaggery is stored above the mesh in storage bin (Fig. 1). During summer season the stored jaggery dries naturally due to aeration process inside the bin and its moisture content decreases upto 6-7% from its initial moisture content 13-14%. Before rainy reason, the lid and holes of the bin are closed tightly and jaggery retains its physical and chemical characteristics.

**Past work done**

Comparative performance of *matka*, glass, jar, polythene bags, urea bags and IISR bins was evaluated by storing jaggery lumps during 1994 and 1996. Observations on various quality factors were taken at monthly interval. The effect of 6 months long storage under different conditions was studied and noted that the final moisture content was lowest in case of IISR bins. The colour was lightest for the sample stored in polybags and glass jars, while it got darkened somewhat in IISR bin. The change in percentage sucrose was not significantly influenced by the storage conditions. The study revealed that IISR bins and polybags are best suited for storage followed by glass jars. Urea bags and *matka* are not suitable for storage in high humidity areas\(^6\). Further, as storage of jaggery is a major problem, the performance of the IISR bin needs to be compared with conventional storage methods. If successful, these technologies shall provide a modern input to the jaggery industry. IISR bins were found to be satisfactory for storage of jaggery in Tarai and plain regions in terms of quality. In hilly areas, there is much consumption of jaggery but at present there are no proper storage methods at market level. Therefore, a need was felt to test the performance of IISR storage bins in cold hilly climate and the study was conducted to see the quality characteristics of jaggery stored under various conditions.

**Methodology**

**Storage of samples under ambient conditions**

Storage behaviour of jaggery samples stored under hilly climatic conditions of Uttrakhand, namely, Almora and Jyolicoat was studied for a period of 5 months. The effect of containers (polythene bags, IISR bins and hanging baskets) was investigated under ambient conditions at these locations. Fresh jaggery was procured from a local jaggery unit, Prem Crushers Kanakpur. For storage, the samples were divided into 3 lots representing 3 types of storage conditions, namely open storage (i.e. in hanging baskets), polythene bags, and IISR bins. Samples were placed in 3 conditions at Jyolikot and Almora (Fig. 2).

**Daily observations**

The daily variations of ambient temperature and relative humidity, dry bulb and wet bulb, temperature at both the location, i.e. Jyolikot and Almora were recorded by using sling psychrometer. The mean temperature during the storage period was recorded as 23.8°C (standard deviation=1.9) at Jyolikot and 26.7°C (standard deviation=4.2) at Almora. The mean relative humidity was recorded as 84.7% (standard deviation=9.8) at Jyolikot and 79.2% (standard deviation=13.6) at Almora. It seems that Jyolikot had generally lower temperature and higher relative humidity compared to Almora and the variability in ambient conditions was more at Almora.

**Monthly observations**

The changes in quality parameters of product such as moisture content, sucrose, reducing sugar and colour were determined at monthly interval. The data collected during the study is summarized in Tables 1 & 2. The data is being analyzed and the response of entrepreneurs at these two sites is being compiled. Samples were drawn randomly at an interval of 30 days.

**Measurement of moisture content**

Approximately 10gm of jaggery is distributed over a surface extender. Sand or aluminium powder is used as surface extender. The surface extender helps in minimizing non–uniform / excessive heating. Digest 25 gm of sand with hydrochloric acid and in a
moisture dish to make it free from organic matter. Wash repeatedly with water to make it completely free from acid. Dry the sand and store it for subsequent use. Dry moisture dish is containing 25 gm sand together with a mixing rod and lid in an oven at 105°C for 2 hrs. Cool in dessicator and weigh \( w_1 \). Add about 10 gm of jaggery and record the combined weight of dish with mixing rod and lid, sand and jaggery sample \( w_2 \). Add 30-40 ml of distilled water in dish and mix the contents and place on a steam water bath for 15 - 20 min, stirring it at an interval of 2-3 min for thorough mixing. Keep the dish in an oven at 75-80°C for 8 -10 hrs for drying. Remove the dish and allow to cool at room temperature in a desiccator before weighing. Repeat the heating and weighing till a constant weight is attained \( w_3 \). The findings were calculated.

The moisture content of jaggery is calculated as:

\[
\text{Percentage of moisture content} = \left( \frac{w_2 - w_1}{w_3 - w_1} \right) \times 100\% \text{(db)}
\]

\[ w_1 = \text{weight of dish + rod + lid + sand}, \quad w_2 = \text{weight of dish + rod + lid + sand+ jiggery}, \quad \text{and } w_3 = \text{weight of dish + rod + lid + sand+ residue after drying}. \]

Reducing sugar

Reducing sugars are based on the property of sugars to reduce copper in the cupric state to cuprous state. A great number of sugars reduce cupric salts but their reducing powers differ from one another. The reducing sugars found in cane products are mainly glucose and fructose with occasionally very small proportions of mannose, lactose and glucose. The glucose and fructose in cane product are not determined separately but together as invert sugar. Total reducing sugar is determined by colorimetric methods.

Optical density of standard solutions

Prepare standard dextrose solution by dissolving 1gm dextrose in 100 ml (100mg/ml) and diluting it by a factor of 100 - 0.1 mg/ml. Take 0.2 ml and 0.4 ml of this solution and make it up to 1 ml. These solutions contain 20 µg and 40 µg of dextrose, respectively.

Optical density of jaggery solution

Prepare N/2 jaggery solution (13gm in 100ml), filter it and dilute it to 1/50. Take 1 ml of filtered

### Table 1—Jaggery storage data at Jyolikot

<table>
<thead>
<tr>
<th>Quality characteristics</th>
<th>Storage conditions</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC %, db</td>
<td>Open storage</td>
<td>11.02</td>
<td>9.86</td>
<td>14.78</td>
<td>-</td>
<td>24.32</td>
</tr>
<tr>
<td></td>
<td>Polythene bag</td>
<td>11.02</td>
<td>11.87</td>
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<td>15.84</td>
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<tr>
<td></td>
<td>IISR bin</td>
<td>11.02</td>
<td>11.85</td>
<td>12.26</td>
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<td>14.89</td>
</tr>
<tr>
<td>Sucrose %, db</td>
<td>Open storage</td>
<td>77.0</td>
<td>72.97</td>
<td>69.79</td>
<td>-</td>
<td>62.19</td>
</tr>
<tr>
<td></td>
<td>Polythene bag</td>
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<td></td>
<td>IISR bin</td>
<td>77.0</td>
<td>75.90</td>
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<td>66.84</td>
</tr>
<tr>
<td>Color (at 540 nm)</td>
<td>Open storage</td>
<td>0.280</td>
<td>0.320</td>
<td>0.330</td>
<td>-</td>
<td>0.405</td>
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<td></td>
<td>Polythene bag</td>
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<td>0.365</td>
</tr>
<tr>
<td></td>
<td>IISR bin</td>
<td>0.280</td>
<td>0.295</td>
<td>0.315</td>
<td>0.325</td>
<td>0.360</td>
</tr>
<tr>
<td>Reducing sugar, % db</td>
<td>Open storage</td>
<td>12.48</td>
<td>12.72</td>
<td>17.09</td>
<td>-</td>
<td>20.81</td>
</tr>
<tr>
<td></td>
<td>Polythene bag</td>
<td>12.48</td>
<td>12.54</td>
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</table>

### Table 2—Jaggery storage data at Almora

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<th>Quality characteristics</th>
<th>Storage conditions</th>
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solution in a Follin's tube and add 1 ml of Nelson's alkaline copper reagent. After shaking thoroughly place it on water bath for 20 min. Remove the tube, cool and add 1 ml of Arsenomolybdate reagent and then mix the contents thoroughly, and make up the volume to 25 ml with distilled water. Read the optical density of the solution at 540 nm after thorough mixing. The amount of reducing sugars in the jaggery solution (in µg) is obtained by comparing the optical density with that of the standard solutions. The reducing sugars are expressed as percent of jaggery mass. The reducing sugars can also be computed using the following formula:

\[ RS = \frac{X}{Y} \times OD \times Df \]

Where,

OD = Optical density of the jaggery solution

Df = Dilution factor = 2x50x100x100/ (10^6x13) = 1/13

Y = Optical density of standard solution

X = Amount of dextrose in standard solution

**Reagents**

Nelson's Reagent (A): Dissolve 12.5gm of sodium carbonate, 10gm of sodium bicarbonate, 12.5gm sodium potassium tartarate and 100gm of sodium sulphate in 400ml of water and make up to 500ml with distilled water.

Nelson's Reagent (B): Dissolve 7.5gm of CuSO_4.5H_2O in 50ml of water and add one drop of concentrated H_2SO_4.

Nelson's alkaline copper Reagent: Mix 1 ml of Nelson's reagent 'B' with 25 ml of Nelson's reagent 'A' just before use.

Arsenomolybdate Reagent: Dissolve 25gm of ammonium molybdate in 400ml of water and add 21ml of concentrated sulphuric acid. Dissolve separately 3gm of sodium arsenate (Na_3HASO_4.7H_2O) in 50ml of distilled water and add it to above molybdate solution and volume is made to 500ml. Store the solution in brown coloured bottle for 24 hrs at 37°C before use.

**Colour**

A N/2 jaggery solution (13gm of jaggery per 100 ml of distilled water) after filtering through Whatman No. 2 filter is taken for colour measurement. The optical density (OD) at 540 nm, as determined by a colorimeter is taken as the colour of the jaggery sample.

**Sugar**

Sucrose in jaggery is computed using the values of spindle Brix and Pol_20 of N/2 jaggery solution

Percentage of sucrose = \((2.0035-0.00758 \times \text{Brix}) \times \text{Pol}_20\)

**Result and discussion**

Tables 1 & 2 clearly indicate that quality characteristics of jaggery samples kept under different ambient conditions are affected by environmental conditions (temperature and relative humidity). The monthly values of moisture content of jaggery stored under various conditions are reported in Tables 1 & 2. The observed moisture content varied from an initial value of -11.02 % to 24.32% for the range of experimental variables. The moisture content increased for a period of 5 months achieving a value of 24.32%. The peak value of moisture content corresponded to the end of September i.e. the maximum intensity of mansoon. This pattern of moisture indicates that jaggery samples were dominantly influenced by external environment. It is evident from the Tables 1 & 2 that the jaggery samples stored in polythene bags and IISR bins were least affected by environmental conditions. Fluctuations in moisture content varied from an initial value of 11.02 % to 15.84% for the samples kept in polythene bag and for the samples kept in IISR bins varied from 11.02% to 14.89 % while this fluctuation in moisture content was quite high achieving a peak value of 24.32% in both the cases, i.e. samples kept in Almora and Jyolicoat. The reasons for minimum changes in moisture content of the jaggery samples kept in IISR bins could be due to its bin structure. Since the perforated sheet was placed at the bottom of the drum and jaggery was stored above the mesh in storage bin, when the samples were kept in the month of May, its moisture content was 11.02%. Drying took place naturally due to aeration process and moisture content decreased but since the rainy season just started after June, its moisture content did not change much as the lids and holes of the bins were closed tightly and exchange of moisture could not take place. In case of polythene bags, moisture migration could not take place and moisture content did not change much.

**Sucrose content:** Sucrose varied from an initial value of 77.0 to 66.42%. No major change was observed for
all the samples stored under various conditions. Maximum sugar was utilized in case of samples stored in open basket storage followed by IISR bins and polythene bags.

Reducing sugar
Reducing sugar ranged from an initial value of 12.48% to 19.04% for all the experimental range. Minimum change was observed for the samples kept in IISR bin followed by the samples kept in polythene bags. Maximum value (19.04% and 20.81%) of reducing sugar was for the samples kept in open baskets followed by polythene bags (16.44% and 16.82%) and IISR bins (15.83 and 15.95%) after 5 months storage placed in Jyolicoat and Almora.

Colour
The colour of the samples was darker in case of samples kept in IISR bin while the samples kept in open baskets and in polythene bags were lighter in colour (Fig. 3). Initial value of colour at 540 nm was observed 0.280 and reached upto 0.410 for the samples stored in open baskets. Minimum changes were observed for the IISR bins samples. This could perhaps be due to the physical condition of samples as affected by environmental conditions. Since the samples kept in open basket were exposed to atmospheric conditions and got infected. Lighter colour was observed for those samples because of oxidation process. In case of samples kept in IISR bin darker colour was observed because of browning that took place due to changes in polyphenols. Fermentation process and oxidation caused darkening of the samples.

Conclusion
The result revealed that good keeping quality of jaggery could be maintained with little changes in sucrose content, colour, total moisture content and reducing sugar under cool hilly climate with IISR drying cum storage bin. Jaggery kept in bin recorded less reduction in quality parameters under cold hilly climate compared to jaggery samples kept in Open baskets.

References