

Effect of Storage Conditions on Keeping Qualities of Jaggery

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Abstract

Storage behavior of jaggery samples, stored in different containers (open, polythene bags and jaggery drying cum storage bin) was studied for a period of six months. The change in quality characteristics such as moisture content, color, sucrose and reducing sugar were determined at an interval of one month. The study was conducted on commercial jaggery to observe the effect of storage period on quality characteristics of jaggery. The experimental data revealed that the jaggery moisture content was increased from an initial value of 12.07% to 22.36% (db) in open storage, while it was decreased to 9.23% (db) in bin and was increased up to 15.84% (db) in polythene bags. Similarly the percent change in sucrose, reducing sugar and color were lesser in bin and polythene bags than in open storage. The color of jaggery became darker during storage. The optical density of jaggery was increased from 0.18 to 0.27. The acidity of the jaggery was increased slightly during storage which was within the safe limits. Good keeping quality of jaggery could be maintained in storage bin. Jaggery, stored in bin, showed less reduction in quality parameters.

Key words : Jaggery, Jaggery drying cum storage bin, Moisture, Sucrose, Color.

Jaggery, commonly known as gur, holds an important place in common Indian diet. It is directly consumed by humans and also used in animal feed. Jaggery is one of the ancient sweetening agents known to man and is an integral part of the rural diet in many countries. Jaggery making is an important cottage industry in India from time immemorial but unfortunately very little has been organized to streamline the production, storage and marketing. The importance of jaggery is further enhanced due to its low cost and high nutritive value. Jaggery contains about 0.4% protein, 0.1% fat, 8 mg/100g calcium, 0.4 mg/100g phosphorus, 11.4 mg/100g iron, 0.6—1.0% total minerals and 3,830 cal / g energy (1). Jaggery making is an important agro processing industry in rural India, where over 2—5 million people earn their livelihood from jaggery and khandsari sector. In India, out of total production of sugarcane, about 30% is crushed by sugar factories, 55% is converted into gur and khandsari and remaining 15 percent is used as seed and for chewing (2). Production of jaggery starts from October and continues up to May, depending on the location. The total jaggery produced is not consumed immediately after production, and is

stored for a period of 10 to 12 months. The major problem associated with jaggery storage is the presence of invert sugars and mineral salts which, being hygroscopic absorb moisture particularly during monsoon season when ambient humidity is high, and lead to spoilage. It has been estimated that more than 10% of jaggery produced in the country worth Rs 40 crore is lost every year due to deterioration (3). This calls for serious attention of all concerned. The need for research on methods of storage of jaggery for improving its keeping quality is even greater in a state like Uttarakhand and Uttar Pradesh, where farmers grow sugarcane mainly for jaggery for home consumption throughout the year. In the past, scientists used the different packaging material for the storage of jaggery. Shinde et al. (4) reported that by using the polythene film of any color, moisture absorption and liquefaction of jaggery can be avoided. Low density polythene film (LDPE) absorbs the water less than 0.01% in 24 hours. Kapur and Kanwar (5) reported that the jaggery stored in tin containers absorbed much less moisture compared to earthen pots. Baboo and Shukla (6) noted that jaggery stored in painted earthen pots could be kept for a longer time as com-

Table 1. Physico-chemical characteristics of freshly prepared jaggery.

Moisture content (%)	12.07 %
Reducing sugar (%)	12.45 %
Non-reducing sugar (%)	76 %
Color (transmittance at 540 nm) (%)	61.1 %
Taste	Acceptable (based on Numerical Scoring Test)

pared to unpainted ones. Singh (7) reported that the plastic containers recorded good retention of shape of jaggery with less reduction in hardness. Roy (8) noted that jaggery can be kept comparatively well in sealed bottles. Mandal et al. (3) reported that heat sealed LDPE packet of 150 gauge was best suitable followed by glass jar, PET jar and used canister of kerosene/edible oil for the storage of jaggery during the monsoon season. Heavy and prolonged monsoon and relative humidity above 70% for more than 10 months in a year are the root causes of spoilage of stored jaggery in the farmers' house. Keeping these in view this investigation was carried out to improve some of the existing methods of storage of jaggery using open pan, LDPE and jaggery drying cum storage bin.

Methods

Storage behavior of jaggery samples stored under different climatic conditions was studied for a period of 300 days. The study was conducted on commercial jaggery. The jaggery obtained was in form of lumps weighing 270 kg. The storage conditions (open, polythene bags and jaggery drying cum storage bin) used in the study were selected keeping in mind their availability in the rural and semi-urban areas as well as their low cost so as to fit the farmers'

pocket. The following storage/packing conditions served as the treatments with three replications in the experiment : T₁ = Open (control) (30 kg capacity), T₂ = Heat sealed low density polythene (LDPE) 150 gauges bags (30 kg capacity), T₃ = Jaggery drying cum storage bin (30 kg capacity).

Freshly prepared hot jaggery was filled in the polythene bags and jaggery drying cum storage bin up to the top so as to drive out the air inside the packing material and to have the minimum possible air space between the lid and the surface of jaggery. This is important to avoid the process of hydrolysis of sucrose present in jaggery. Jaggery was also stored in open pan (control). The packaging was done at the production site in the mid of April. The stored jaggery under different treatments was analyzed for parameters viz. moisture content, reducing sugar (glucose), non-reducing sugar (sucrose) and color. Initial pre-monsoon analyses of the original sample was done in April. Thereafter, the samples were analyzed at monthly intervals from June to September.

Analysis of Quality Parameters

Moisture Content. Five g jaggery with few drops of absolute alcohol was dried to constant weight at 70 C in a hot-air oven (3).

Reducing Sugar (Glucose). Using colorimeter, the reducing sugar of jaggery in terms of glucose per cent was determined by plotting the optical density of 100 ppm jaggery solution against the standard glucose curve. The standard curve for glucose was obtained by plotting the optical densities of pure glucose solution of known concentrations. Color development was done with Anthrone's reagent, which reacts with invert sugars to yield hydroxymethyl furfural imparting a green color. Before addition of Anthrone's reagent, jaggery solution was decolorized

Table 2. Moisture variation of jaggery for different storage/packing conditions during the storage period. Values are the mean \pm SD of three replicates. Values followed by the same letter in same row and column are not significantly different ($P < 0.05$).

Treatment	Moisture content (%)					
	Apr	May	Jun	Jul	Aug	Sep
Open pan	12.07 \pm 0.21 ^a	9.55 \pm 0.43 ^a	9.20 \pm 0.60 ^a	13.38 \pm 0.52 ^a	16.86 \pm 0.23 ^a	22.36 \pm 0.33 ^a
Polythene bag	12.07 \pm 0.21 ^{ab}	11.18 \pm 0.06 ^{ab}	11.22 \pm 0.06 ^{ab}	11.92 \pm 0.31 ^{ab}	14.29 \pm 0.40 ^{ab}	15.84 \pm 0.26 ^{ab}
Drying cum storage bin	12.07 \pm 0.21 ^b	9.99 \pm 0.03 ^b	7.08 \pm 0.25 ^b	7.86 \pm 0.18 ^b	8.23 \pm 0.09 ^b	9.23 \pm 0.05 ^b

Table 3. Change in reducing sugar of jaggery for different storage/packing conditions during storage period. Values are the mean \pm SD of three replicates. Values followed by the same letter in same row and column are not significantly different ($P < 0.05$).

Treatment	Reducing sugar (%)					
	Apr	May	Jun	Jul	Aug	Sep
Open pan	12.45 \pm 0.32 ^a	12.69 \pm 0.18 ^a	17.06 \pm 0.41 ^{ab}	20.13 \pm 0.29 ^b	21.2 \pm 0.51 ^b	21.32 \pm 0.49 ^b
Polythene bag	12.45 \pm 0.32 ^c	12.51 \pm 0.23 ^c	14.22 \pm 0.47 ^{cd}	15.26 \pm 0.51 ^d	16.79 \pm 0.46 ^d	18.32 \pm 0.12 ^d
Drying cum storage bin	12.45 \pm 0.32 ^c	12.69 \pm 0.48 ^c	14.09 \pm 0.14 ^{cd}	14.82 \pm 0.34 ^d	15.91 \pm 0.16 ^d	15.98 \pm 0.31 ^d

using phosphate free activated charcoal and filtered through Whatman No. 1 filter paper (3).

Non-Reducing Sugar (Sucrose). Sucrose per cent was calculated from the difference between total reducing sugar (TRS) and the free reducing sugar (FRS) or glucose (3).

$$\text{Sucrose} = (\text{TRS} - \text{FRS}) \times 0.95$$

Total reducing sugar (TRS) was obtained by adding 1ml of HCL (60% by volume) to 25 ml of 100 ppm decolorized jaggery solution and was heated up to a temperature of 68 C in a water bath for ten minutes. After keeping it for another five minutes at 68 C, the solution was neutralized by adding sodium bicarbonate. The optical density of this inverted solution was recorded and plotted against the standard glucose curve.

Color. Using colorimeter, the percentage transmittance of N/2 solution of jaggery was recorded at 540 nm (3).

Results and Discussion

The freshly prepared jaggery was analyzed for its physico-chemical characteristics at monthly intervals from mid of April to mid of September. Moisture content of fresh jaggery was 12.07% (db) (Table 1) which was much higher than the requirement of 5 to 7% based on Bureau of Indian Standards (9). Soft jaggery is preferred over the hard in Uttarakhand and Uttar Pradesh which aggravates the problem of deterioration in storage as large amount of moisture impairs the keeping quality of jaggery. Usually low initial moisture content and high solids in jaggery do not support their growth and multiplication. The freshly prepared jaggery was golden yellow in color with 61.1% transmittance and acceptable taste.

Moisture Content

ANOVA revealed that there was significant ($P < 0.05$) effect of storage conditions and storage period on moisture content of stored jaggery. Moisture content of jaggery stored in open pan significantly ($P < 0.05$) differ from that of stored in storage bin. However, the moisture present in jaggery stored in polythene was not significantly ($P > 0.05$) differ either from that of stored in open pan or storage bin. From April to September there was no significant ($P > 0.05$) increase or decrease in moisture of stored jaggery. During the experimental storage period, the moisture content of jaggery stored in open pan and polythene bag was increased by 85 and 31% respectively, while it was decreased by 24% in jaggery storage bin (Table 2). Among all the treatments, jaggery storage bin was found to be the best for the storage of jaggery during the monsoon season. LDPE was found the second best packing material next to storage bin. The similar findings were reported by Kapur and Kanwar (5).

Reducing Sugars

ANOVA showed that storage conditions and storage period had the significant ($P < 0.05$) effect on reducing sugar of stored jaggery. Reducing sugar of the jaggery stored in open pan was significantly ($P < 0.05$) differ from that of stored in polythene and bin, whereas, reducing sugar of jaggery in polythene was not significantly ($P > 0.05$) differ from storage bin jaggery. Reducing sugar of stored jaggery increased insignificantly ($P > 0.05$) from April to June (summer) and from June to September (monsoon), but reducing sugar had a significant ($P < 0.05$) increase from May to July. The initial amount of reducing sugar in freshly prepared jaggery was 12.45%. Table 3 shows that during storage the reducing sugar of stored jaggery

Table 4. Variation in non-reducing sugar of jaggery stored in different storage/packing materials during the storage period. Values are the mean \pm SD of three replicates. Values followed by the same letter in same row and column are not significantly different ($P < 0.05$).

Treatment	Non-reducing sugar (%)					
	Apr	May	Jun	Jul	Aug	Sep
Open pan	76.00 \pm 0.04 ^a	71.94 \pm 0.43 ^a	68.76 \pm 0.18 ^c	65.19 \pm 0.21 ^d	61.62 \pm 0.27 ^d	60.05 \pm 0.67 ^d
Polythene bag	76.00 \pm 0.04 ^b	73.57 \pm 0.11 ^b	70.31 \pm 0.38 ^d	65.89 \pm 0.25 ^c	65.18 \pm 0.37 ^e	65.08 \pm 0.19 ^e
Drying cum storage bin	76.00 \pm 0.04 ^b	73.40 \pm 0.09 ^b	70.00 \pm 0.27 ^d	66.20 \pm 0.06 ^c	65.70 \pm 0.13 ^e	64.50 \pm 0.11 ^e

in dry cum storage bin was increased upto 15.98% followed by polythene bag (18.32%) and open pan (21.32%). Shinde et al. (4) reported that jaggery wrapped in polythene film showed no inversion of non-reducing sugars during storage and there was almost no change in the reducing sugar values even at the end of December. Uppal and Sharma (10) reported similar findings. They noted that there was no difference in the reducing sugar of jaggery stored in airtight glass and plastic containers as revealed in the post-monsoon analysis in December. Singh (7) observed that the jaggery stored in plastic containers had less increase in reducing sugar. The increase in reducing sugar in open pan and polythene was higher than that of storage bin because of more moisture absorption by jaggery in open pan and polythene.

Non-Reducing Sugar

ANOVA depicted that storage condition and storage period had significant ($P < 0.05$) effect on non-reducing sugar of stored jaggery. Non-reducing sugar of the jaggery stored in open pan significantly ($P < 0.05$) differ from that of stored in polythene and bin, whereas non-reducing sugar of jaggery in polythene was not significantly ($P > 0.05$) differ from storage bin jaggery. Reducing sugar of stored jaggery increased

significantly ($P < 0.05$) from April to July (Summer) and thereafter increased insignificantly ($P > 0.05$) during monsoon. Non-reducing sugar of freshly prepared jaggery was 76%. During storage, the jaggery stored in polythene bag had the minimum decrease in reducing sugar by 5 units followed by storage bin (5.5 units) while it was maximum in open pan jaggery by 16 units after the rainy season (Table 4). Shinde et al. (4) showed that there was almost no change in non-reducing sugar of jaggery wrapped in polythene even at the end of December. Next to polythene, glass jar and PET jar also checked the inversion of sucrose of stored jaggery after the monsoon season.

Decrease in sucrose or increase in reducing sugar was more or less in accordance with the increase in moisture in the various storage/packing conditions. Hence, it can be inferred that high absorption of moisture creates conditions for inversion.

Color

ANOVA described that there was a significant ($P < 0.05$) effect of storage conditions and period on color of jaggery. Color of jaggery stored in open pan significantly differ from that of stored in polythene and bin, while jaggery in polythene did not significantly differ from the jaggery stored in bin. Color of stored jaggery significantly darkened from April to

Table 5. Change in color of gur kept in different packing materials during the period of storage (average of three replications). Values are the mean \pm SD of three replicates. Values followed by the same letter in same row and column are not significantly different ($P < 0.05$).

Treatment	Transmittance (%)					
	Apr	May	Jun	Jul	Aug	Sep
Open pan	54.9 \pm 0.06 ^a	48.0 \pm 0.23 ^{ab}	44.2 \pm 0.08 ^{bc}	41.6 \pm 0.12 ^{cd}	36.4 \pm 0.04 ^{cd}	33.4 \pm 0.16 ^d
Polythene bag	57.3 \pm 0.03 ^c	53.7 \pm 0.05 ^{ef}	49.0 \pm 0.07 ^{fg}	47.1 \pm 0.01 ^{gh}	46.5 \pm 0.14 ^{gh}	45.1 \pm 0.08 ^h
Drying cum storage bin	57.1 \pm 0.05 ^c	52.7 \pm 0.02 ^{ef}	48.2 \pm 0.09 ^{fg}	46.7 \pm 0.17 ^{gh}	45.8 \pm 0.04 ^{gh}	43.2 \pm 0.03 ^h

July and thereafter color changed insignificantly. The color of jaggery was changed from golden yellow to brown by the end of storage period for all the treatments.

Table 5 shows that the transmittance of jaggery stored in polythene was decreased by 21% followed by storage bin (24%) and open pan (39%) during storage period. This corroborates the findings of Uppal and Sharma (10). The jaggery stored in polythene had the lighter color, whereas open pan jaggery was observed as darker in color. Color of stored jaggery darkened in direct proportion with rise in invert sugar percent and moisture content (3). Under high relative humidity jaggery attains moisture leading to decomposition of sucrose resulting in a change in color as the anthocyanin is not removed completely in the process of jaggery making (11).

Conclusion

On the basis of storage qualities viz. moisture, reducing, non-reducing sugar and color, it was observed that open pots were not suitable for storage jaggery during the monsoon season. The best packing material in terms of preventing ingress of atmospheric moisture and for maintaining the keeping quality of jaggery stored at village/domestic level during the monsoon season was drying cum storage bin followed by polythene bag as both allowed the lesser moisture absorption, lesser increase in reducing, non-reducing sugar and lesser change in color as com-

pared to open pan during the storage period from April to September.

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