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Deterioration of *Gur* during storage—certain correlation studies on moisture, reducing sugars and polarisation and total sugars relationship

by

P. SUBRAMANIYAM[1] and S. VAIDYANATHAN[2]

Synopsis: The results of correlation studies on the relationship between moisture and reducing sugars, moisture and polarisation, moisture and total sugars and reducing sugars and total sugar of the *gur* stored under improved and ordinary godown conditions are reported in this paper. The harmful effect of moisture on the keeping quality of *gur* stored in the ordinary godown has also been discussed.

Introduction: Storage of *gur* specially during the monsoon is a difficult problem, as the *gur* stored undergoes heavy deterioration in quality and loss in weight by the running out of molasses mainly due to the absorption of the moisture in the surrounding atmosphere. On account of moisture absorption, the *gur* becomes very soft and sticky and gets partially or completely liquified. Thus, the original shape, hardness and crystalline structure of *gur*, are completely lost. Absorption of moisture also simultaneously increases the activities of micro-organisms as a result of which a considerable quantity of sucrose gets inverted which in turn accelerates the absorption of more and more moisture. Based on the above phenomena, an attempt has been made in this paper to establish a relationship between moisture in *gur* and other chemical criteria like reducing sugars, polarisation and total sugars during the period of storage.

Review of Literature: Gundu Rao and Ramiah (1961) have observed that the uptake of moisture causes the *gur* to acquire soft and syrupy nature and it promotes inversion which in turn causes loss of crystallinity, structure and hardness and also predisposes *gur* to fermentation by yeast. Thus, moisture, on which depends the influence of temperature and of micro-organisms on the deterioration of *gur*, becomes the chief enemy of *gur* in storage. Khanna and Chakravarti (1955) pointed out that the agency causing the loss suffered by *gur* in storage was the high atmospheric humidity from which mainly the product in storage must be protected. Varahalu (1938) after conducting experiments under laboratory conditions on the properties of jaggery in relation to moisture indicated that at 75 per cent relative humidity both good and bad types of jaggery were taking up water and this property may be useful in the study of the conditions for the storage of jaggery in bulk for commercial purposes.

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[1] Assistant in Chemistry, Central Sugarcane Research Station, Cuddalore. [2] Assistant Agronomist, Sugarcane Research Station, Melalathur, North Arcot District.

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Materials and Methods: Based on the knowledge referred above, an experiment to study the physical and chemical changes involved in the *gur* under storage was started in 1961—'62 and continued in 1962—'63 at the Sugarcane Research Station, Gudiyatham. For this purpose, an improved *gur* godown provided with moisture proof contrivances like damp proof flooring, doors and ventilators was constructed. The constructional details and other aspects of this godown have been dealt with in a separate paper by the authors (1964). An ordinary *gur* godown commonly used by the ryots has been used for storage of *gur* as control. The following method of storage was adopted.

Improved Gur Godown: Five tons of *gur* are stored in loose heap on asphalt flooring covered with palmyrah mats.

Ordinary Gur Godown: One ton of *gur* was stored in loose heap on cement flooring over which dry *begasse* was spread and covered with palmyrah mats.

The experiment was started in the month of May and completed in February. Monthly observations were made with reference to colour and consistency of *gur*. Moisture content, polarisation, reducing sugars and total sugars were estimated every month following the methods outlined by Roy (1951). The results are expressed on oven dry basis and are presented in Table I.

Total correlations between moisture per cent and reducing sugars per cent, moisture per cent and polarisation per cent, moisture per cent and total sugars per cent and reducing sugars per cent and total sugars per cent were worked out and the corresponding regression equations were also drawn. The magnitude of total correlation observed between the different factors are furnished in Table II.

In addition to the above factors, relative humidity values in the improved and ordinary godowns were also recorded daily and the average values for the peak rainy months are furnished in Table III.

Results and Discussion: From the data furnished in Table I, it is seen that the *gur* stored in the improved godown has kept up its consistency throughout the period of storage for about 10 months. Even during the peak rainy months of September and October, the *gur* has not lost its original shape and crystalline structure. Increase in moisture content is very low as the period of storage advances. On account of the moisture proof nature of the improved godown, the increase in moisture has been checked and the consequential inversion of sucrose has also been arrested.

TABLE I.

Showing the physical and chemical changes involved in gur under storage (Results expressed on oven—dry basis)

(Average values for 1961—'62 and 1962—'63)

Month of analysis	Consistency		Moisture per cent		Reducing Sugars per cent		Polarisation per cent		Total Sugars per cent	
	Improved godown	Ordinary godown	Improved godown	Ordinary godown	Improved godown	Ordinary godown	Improved godown	Ordinary godown	Improved godown	Ordinary godown
May ...	Hard	Hard	5·26	5·68	11·31	12·43	76·2	75·7	86·49	86·55
June ...	,,	,,	4·80	5·72	10·94	12·22	77·0	75·7	86·86	86·19
July ...	,,	,,	4·89	5·46	11·24	12·28	76·2	74·7	86·30	87·05
August ...	,,	Slightly soft	5·27	6·83	11·28	11·84	76·3	75·7	86·38	87·67
September ...	,,	Very soft sticky	5·45	7·27	11·28	13·48	76·3	73·2	86 28	85·32
October ...	,,	Partially liquified	5·91	8·48	11·20	16·05	75·9	69·4	85 27	84·01
November ...	,,	Heavy fungal attack	6·16	11·01	11·12	17·46	76·2	66·7	85·85	84·31
December ...	,,	,,	6·16	12·00	11·44	20·02	76·2	63·2	86·15	83·33
January ...	,,	,,	6·67	13·58	11·55	20·41	76·1	62·2	86·08	82·56
February ...	,,	,,	6·70	14·33	11·56	20·95	76 0	61·0	85·99	82·12

TABLE II.

Showing the value of the total correlation and regression equations.

Particulars	Correlation coefficient		Regression equation		
	Improved godown	Ordinary godown	Improved godown	Ordinary godown	Value of X and Y
1. Moisture % × Reducing Sugars %	0·5582 N. S.	0·9773*	$Y = 10{\cdot}42 + 1{\cdot}441\ X$	$Y = 5{\cdot}96 + 1{\cdot}078\ X$	Y = Reducing Sugars % X = Moisture %
2. Moisture % × Pol %	(—) 0·2416 N. S.	(—) 0·9811*	$Y = 76{\cdot}6 - 0{\cdot}0979\ X$	$Y = 85{\cdot}54 - 1{\cdot}747\ X$	Y = Pol %: X = Moisture %
3. Moisture % × Total Sugars %	(—) 0·4341 N. S.	(—) 0·9335*	$Y = 87{\cdot}10 - 0{\cdot}1534\ X$	$Y = 89{\cdot}66 - 0{\cdot}5258\ X$	Y = Total Sugars % X = Moisture %
4. Reducing Sugars % × Total Sugars %	(—) 0·4837 N. S.	(—) 0·9612*	$Y_1 = 95{\cdot}68 - 0{\cdot}8381\ X_1$	$Y_1 = 92{\cdot}71 - 0{\cdot}4969\ X_1$	Y_1 = Total Sugars % X_1 = Reducing Sugars %

N. S. = Not Significant and * = Significant at P = 0·01

TABLE III.

Showing the average values of relative humidity in the improved and ordinary gur godowns.

(Average for 1962 and 1963)

	Relative humidity per cent		
	September	October	November
Improved gur godown ...	70·0	73·3	73·9
Ordinary gur godown ...	77·6	82·5	84·0

Other chemical constituents like Polarisation, reducing sugars and total sugars do not show any appreciable change in their magnitude. On the other hand, in the ordinary godown, moisture content steadily increases and the increase is very sharp on the onset of rainy season i. e. from September. On account of heavy moisture absorption, the *gur* has become soft in the month of August and the degree of deterioration is found to increase as the period of storage advances. The *gur* has become very soft and sticky and finally the whole thing gets converted into a semi solid.

The original shape and crystalline structure of the *gur* are completely lost. The influence of heavy moisture absorption on the values of polarisation, reducing sugars and total sugars of *gur* is also considerable. The relative humidity values furnished in Table III also indicate that relative humidity in the improved godown (70 per cent to 73·9 per cent) during the rainy months (September to November) is less than in the ordinary godown (77·6 per cent to 85·0 per cent). The high values of relative humidity in the ordinary godown may be responsible for moisture absorption by the jaggery stored in the ordinary godown. This finding is in corroboration with that of Varahalu (loc-cit).

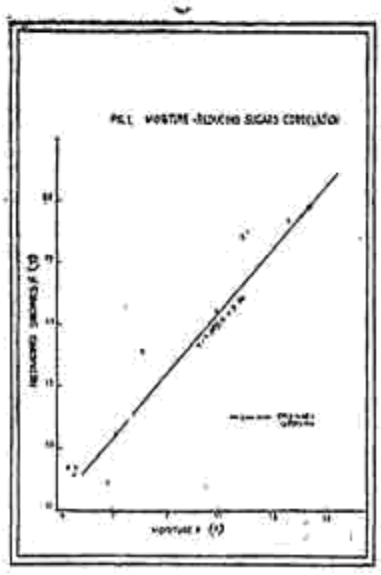
The degree of formation of reducing sugars is increased and the value of Pol and total sugars have decreased as the moisture content increases. The inversion of sucrose (formation of reducing sugars) and consequent decrease in Pol and total sugars have adversely affected the keeping quality of *gur*.

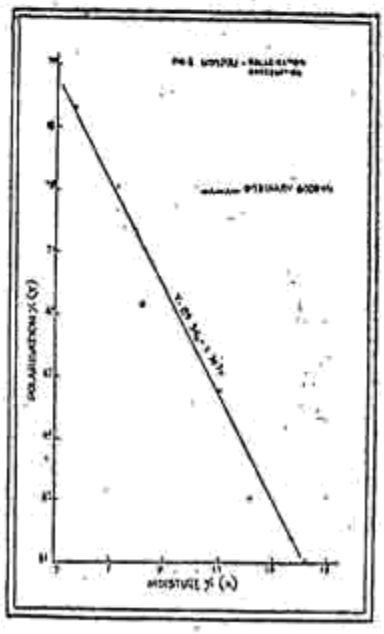
Since moisture content is the basic factor responsible for the deterioration of *gur* under storage, correlation coefficients were worked out between (a) moisture per cent × reducing sugars per cent (b) moisture per cent × polarisation per cent (c) moisture per cent × total sugars per cent. As there had been good correlations between moisture per cent and reducing sugars per cent and moisture per cent and total sugars per cent, the correlation coefficient between reducing sugars per cent and total sugars per cent was also worked out. The correlation coefficients relating to the improved and ordinary godowns are furnished in Table II. It is seen that correlation coefficients relating to the improved godown are found to be not significant even at $P = 0{\cdot}05$. In other words the chemical characteristics of *gur* such as polarisation, reducing sugars and total sugars are not affected within the narrow range of moisture variations available. This lack of wide variations in moisture values has resulted in the poor correlation obtained for the *gur* characters in the improved godown conditions.

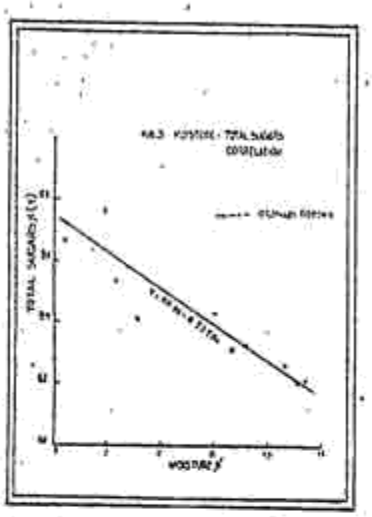
This point, clearly indicates that the harmful effect of moisture on the *gur* under storage in the improved godown is not present because of the moisture proof contrivances like asphalt flooring and damp proof doors and ventilators. However, in the ordinary godown, correlation coefficient worked out between moisture per cent and reducing sugars per cent is found to be positive and is as high as 0·9773 and is significant at 0.01 level. This clearly shows that harmful effect of moisture content is in a regular fashion in the ordinary godown and is highly responsible for the increase in reducing sugars and decrease in polarisation and total sugars which finally brings about the deterioration of *gur*.

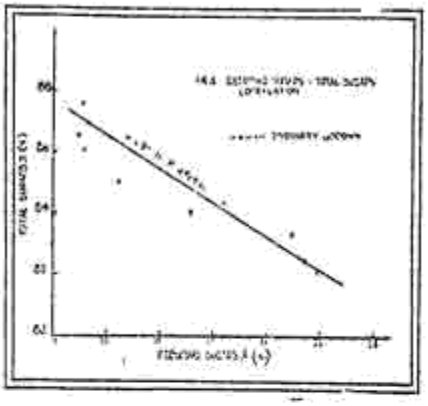
The regular harmful effect of moisture on the *gur* stored in ordinary godown is also well corraborated by close correlations between the different factors mentioned above. The high and negative correlation existing between reducing sugars and total sugars in the ordinary godown seems to indicate that there is a small reduction in the total sugar content of jaggery during the course of storage where as the same is not seen in improved godown.

Regression Studies: The regression equation representing the correlation between (a) Moisture per cent × reducing sugars per cent (b) Moisture per cent × Pol per cent (c) Moisture per cent × total sugars per cent (d) Reducing sugars per cent × total sugars per cent in the *gur* stored in ordinary godown are given in the graphs (Fig. 1, 2, 3 and 4). Such regression studies were not attempted for the data obtained from the improved godown.









The regression co-efficients in the ordinary godown are high in respect of equation 1, 2 and 3. This indicates that the rate of increase of moisture is very high in the ordinary godown. It is also observed from the graphs (Fig. 1, 2, 3 and 4) that the points representing moisture and reducing sugars, moisture and polarisation, moisture and total sugars, reducing sugars and total sugars are well dispersed in respect of ordinary godown and the regression lines are also very steep. This also indicates that the rate of change of pol, reducing sugars and total sugars per unit change in moisture is very high in the ordinary godown.

Summary and Conclusions: It has been indicated that moisture content in *gur* is mainly responsible for the deterioration of *gur* under storage. This point has been proved by the better keeping quality of *gur* stored in the improved godown with moisture proof contrivances. Correlation coefficients worked out between moisture and other chemical characters of *gur* stored in the ordinary godown have indicated that there is a strong positive correlation between moisture per cent and reducing sugars per cent and strong negative correlation between moisture per cent and Polarisation per cent and moisture per cent and total sugars per cent and reducing sugars per cent and total sugars per cent showing that increase in moisture and consequent decrease in polarisation and total sugars and increase in reducing sugars are responsible for the deterioration of *gur* under storage. Correlatian coefficients between moisture and other chemical characters of *gur* stored in the improved godown were found to be not significant indicating that the harmful effect of moisture on the *gur* is not in a regular fashion in the improved godown. The trend in the change of pol, reducing sugars and total sugars per unit change in moisture in respect of the ordinary *gur* godown has also been indicated by means of regression equations.

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