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EFFECT OF EDIBLE COATING AND PACKAGING ON MICROBIOLOGICAL CHARACTERISTICS OF Jaggery

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"Effect of edible coating and packaging on microbiological characteristics of jaggery"

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Jaggery industry is one of the old and large agro-processing cottage industries in India. However it has problems related to keeping quality. The main problems associated with jaggery storage are liquefaction and deterioration of color. This investigation was undertaken to determine the quality characteristics of jaggery samples for 18 weeks with different treatments of edible coating, packaging and storage conditions. The treatments given to jaggery were: storage of jaggery at ambient conditions (Amb), uncoated and open (U/O), coated and open (C/O), uncoated and packaged in LDPE (U/P), coated and packaged in LDPE (C/P), uncoated and vacuum packaged (U/V) and coated and vacuum packaged (U/V), stored at 30±1 ºC in incubator. The storage study revealed that the yeast and mould count and total viable count increased significantly ($p \leq 0.01$) as the storage period increased, however, moisture content and water activity followed a decreasing trend during storage study. The results of the study concluded that jaggery with edible coating along with vacuum packaging (C/V) samples, stored at 30±1ºC in incubator had significantly better quality characteristics than other treatments up till 18 weeks. Uncoated and vacuum packaged (U/V) jaggery was preferred most by sensory panel, followed by coated and vacuum packaged (C/V). It was concluded from the present study that problems because of absorption of moisture and microbial attack could be overcome by applying protein based edible coating on jaggery, packing it under vacuum and storing it under controlled conditions of temperature and relative humidity.

Key words: Edible coating, jaggery, packaging

INTRODUCTION

Gur or jaggery is one of the ancient sweetening agents known to man and is an integral part of the rural diet in many countries (Mandal, 2006). Jaggery is a natural sweetener made from sugarcane juice simply by evaporation. It contains an enormous wealth of minerals, protein, vitamin and useful sugar (Makde, 2006) Jaggery, being a low cost, traditional, eco-friendly and nutritive sweetener, offers a viable alternative to sucrose. It may look less attractive than crystal white sugar but it is a healthier food. Jaggery is available in the market mainly in three forms namely solid jaggery, liquid jaggery and granular jaggery. Of the total production of jaggery in India, approximately 80 per cent of the jaggery is prepared in solid form and the remaining 20 per cent is prepared in liquid as well as granular form. In India, out of the total sugarcane production of 17.3 million MT, 8.2 million MT is converted to jaggery (*gur*) (Singh, 2009). The method is not satisfactory and results in considerable spoilage and losses. Composition and storage conditions of jaggery (both physical and chemical) are important factors that determine the keeping quality of product. During storage, jaggery, basically suffers from four types of deterioration: physical, chemical, biological and microbiological. The main problems related to solid jaggery storage are running-off (liquefaction) and deterioration of color during storage. These problems are because of absorption of moisture and microbial attack (Kunte, 1952). Rao *et al.* (1973) found that jaggery from mature cane recorded less reduction in quality parameters under cold storage compared to jaggery from immature and over aged cane. Fermentation brought about by yeasts and complex biochemical degradation caused by moulds is the usual forms of microbial deterioration. Moisture uptake resulting from exposure to humid atmosphere either during handling or storage is primarily responsible for most of the storage ills.

Physically, it destroys the texture through dissolution and liquefaction. It also dilutes the sugars and lowers the sweetness. Chemically, it promotes inversion of sucrose which in turn leads to loss of texture, structure and body hardness. Moisture gain also encourages microbial infection and degradation. Jaggery also becomes more hygroscopic at higher temperatures (Verma, 1985). Drying of jaggery to reduce its initial moisture content is essential for storage (Baboo and Ghosh, 1985). Neutralization of sugarcane juice acidity during boiling for preparation of jaggery with calcium carbonate and sodium carbonate resulted in lower absorption of moisture by the jaggery blocks, during storage (Shinde *et al*., 1983). The problem of storage of various food products, especially, jaggery has numerous complications and no standard method of storage can be suitable for the whole of India. The methods of storage differ in different tracts according to climatic conditions, local customs and resources. In small quantities, farmers store jaggery in earthen pots covered with lids and tide with a covering of muslin cloth. In large quantities jaggery is stored in *kothies* or earthen granaries with mouth covered. In western districts, jaggery is stored in closed rooms. *Gur bhelies* are stacked on the mat in layers. Sometimes the jaggery is packed in gunny bags before stacking. In eastern districts, where humidity is high, jaggery is stored on raised wooden or bamboo platforms, about 3 feet above the ground with *bhusa* lining on top and bottom and covered with gunny bags on all sides (Roy, 1951). No special or standardized method of storage is followed for preserving jaggery in market places. Sometimes old bags, mats and so on. are used for giving a lining at the bottom and for covering on the top. To meet the requirement, selection and design of appropriate package should consider the protection against contamination and moisture gain during transport and storage of jaggery. In addition, package must be capable of providing safety against physical damage caused by impact or superimposed weight when jaggery is transported or stored. A large number of plastics have been widely accepted for this purpose. All these deteriorations can be arrested through well designed storage environment, storage structure and control of storage conditions, provided the product meets the minimum quality requirements before being stored. The polyethylene film wrapping helped to check the running off of the Jaggery completely, however it has not helped to check the darkening of the color. The grass wrapping was useful in maintaining the original color of jaggery (Shinde *et al*., 1981). Shinde *et al*. (1983) also reported that the black coloured polythene could be used directly without grass cover to avoid marked deterioration of color of jaggery as well as absorption of moisture and running off during storage. At 7-9°C, with increase in storage time, there was decrease in quality of jaggery but there was complete check of microbial growth till storage period of 2 years and 8 months with some changes in physicochemical characteristics and visual observations along with smell like old jaggery (Uppal, 2002). The growth of *S. aureus* in Bologna was markedly inhibited by vacuum packaging (Christiansen *et al.,* 1965). Attempts were made by several authors to prevent microbial growth and to increase the shelf life of jaggery based on wrapping or packaging in common packaging materials, in airtight containers, polyethylene and storage under ambient and refrigerated cold store. Although many packaging materials have been studied with the aim of increasing shelf life, no data are yet available on applying edible coating and packaging under vacuum for a similar purpose. The present work was planned to study the effect of Whey Protein Concentrate (WPC) based edible coating to improve shelf life of jaggery. WPC based edible coating is known to have desirable barrier properties against moisture, oxygen, gases and so on., which comes along with different packaging or conditions viz. packaging in low density polyethylene (LDPE)/ laminates for vacuum packaging and may have better results in keeping quality of jaggery with better characteristics when jaggery is stored at room temperature.

MATERIALS AND METHODS

Materials

Fresh jaggery samples were procured from local small scale jaggery manufacturing unit situated at Kashipur, Uttarakhand, India. Whey protein concentrate (DARS) Specific, Tansen Road, Gwalior (Madhya Pradesh) and Glycerol (M/S Himedia Laboratories, Mumbai, India) were used for coating preparation. Low density polyethylene (LDPE) packets (thickness 50 microns) and laminates (thickness 80 microns) of standard size (half Kg capacity) were procured from the market of Haldwani, Uttarakhand were utilized for packaging of collected samples of jaggery.

Methods

Packaging of jaggery

About 400 grams of jaggery samples was taken, packaged and given various treatments designated as T1: Uncoated and without packaging (U/O), T2: Uncoated and LDPE packaged (U/P), T3: WPC-coating and without packaging (C/O), T4: WPC-coating and LDPE packaged (C/P), T5: Uncoated and vacuum packaged in laminates (U/V), T6: Coated and vacuum packaged in laminates (C/V) and T7: Control sample (Amb) without coating and without packaging. Control jaggery samples were stored at ambient conditions in open environment whereas other samples were kept in incubator at 30±1ºC in isolated environment for a period of 18 weeks. Different analyses were carried out at an interval of three weeks during the storage study.

Analysis of stored jaggery

All the stored samples of jaggery were subjected to

Table 1: Effect of storage on moisture content of jaggery samples

Storage	Amb	U/O	C/O	U/P	C/P	U/V	C/V
0 week	11.72±0.5	11.72±1.5	10.31±1.1	11.72±1.7	10.31±0.5	11.72±2.5	10.31±0.9
3 weeks	11.0±2	11.71±0.99	9.05±1.3	14.2±1.45	13.94±1.92	11.0±2	9.05±2
6 weeks	7.62±1.59	7.59±0.25	7.22±0.61	15.8±1.09	14.62±0.44	7.62±1.59	7.62±1.59
9 weeks	5.38±0.49	6.09±1.43	7.13±1.2	-	-	6.56±1.17	7.07±0.9
12 weeks	3.84±0.0788	2.65±1.09	1.78±0.08	-	-	5.65±1.88	3.82±1.33
15 weeks	1.66±0.58	2.23±1.07	1.66±0.16	-	-	2.94±0.98	3.49±1.53
18 weeks	1.29±0.45	2.06±0.8	1.44±0.18	-	-	2.4±0.74	2.81±0.74
F value	**	**	**	**	**	**	**

Mean value ± S.D
Values shown in table average of triplicates
-: Not determined further as sample was unacceptable due to liquefaction
** Significant at 1% level of significance

Table 2: Effect of storage on water activity of jaggery samples

Storage	Amb	U/O	C/O	U/P	C/P	U/V	C/V
0 weeks	0.812±0.001	0.812±0.001	0.802±0.002	0.812±0.001	0.802±0.015	0.812±0.03	0.802±0.004
3 weeks	0.723±0.036	0.712±0.025	0.700±0.001	0.849±0.003	0.858±0.027	0.723±0.001	0.713±0.005
6 weeks	0.656±0.001	0.614±0.005	0.657±0.004	0.884±0.067	0.883±0.015	0.656±0.002	0.656±0.007
9 weeks	0.624±0.001	0.565±0.001	0.591±0.002	-	-	0.624±0.001	0.624±0.0014
12 weeks	0.572±0.001	0.521±0.003	0.532±0.001	-	-	0.572±0.002	0.595±0.003
15 weeks	0.532±0.0034	0.512±0.018	0.494±0.009	-	-	0.532±0.015	0.616±0.032
18 weeks	0.521±0.003	0.494±0.009	0.445±0.256	-	-	0.521±0.03	0.606±0.013
F value	**	**	**	**	**	**	**

Mean value ± S.D
Values shown in table average of triplicates
-: Not determined further as sample was unacceptable due to liquefaction
* *Significant at 1% level of significance

analysis for moisture content (Association of Official Analytical Chemists AOAC, 1984), water activity measured by water activity meter (M/S GBX Scientific Instrument, France) and microbiological analysis for SPC and Yeast and Mould count (APHA, 1992). Statistical analysis was done by employing Analysis of Variance (ANOVA) technique of Snedecor and Cochran (1968).

RESULTS AND DISCUSSION

Fresh jaggery samples at the time of packaging had moisture content of 11.72% with water activity of 0.812 while total viable count (cfu/g) was noted as 1.98×10^3 to 2.45×10^3 cfu / g. Changes in moisture content during storage is shown in table 1.

Moisture of samples kept at ambient conditions decreased from 11.72% to 1.29% after storage of 18 weeks. Our results are in accordance with those reported by Mandal *et al*. (2006). However, observations made by Shinde *et al*. (1983) were contradictory to our results. Observed decrease in moisture content may be attributed to the rapid increase in temperature and decrease in relative humidity during storage period (Table 4) that might have encouraged the rapid moisture loss. The moisture content of jaggery samples with edible coating and vacuum packaging stored at 30±1ºC was found maximum (2.81%) at the end of 18 weeks of storage as compared to 1.29% moisture in samples kept under ambient conditions. This shows that coating of jaggery samples helped in retaining moisture content up to some extent while ambient conditions led to excessive moisture loss from jaggery rendering the samples to be almost dry, granular and powdery.

Changes in water activity values for jaggery (Table 2) showed that water activity followed a decreasing trend during 18 weeks of storage due to the atmospheric conditions prevailing during study period where relative humidity decreased while atmospheric temperature increased simultaneously. Coating of jaggery samples showed significant ($p\leq0.01$) differences in water activity as noted by marked differences in values obtained for uncoated and coated samples. Similarly, various packaging treatments, under different storage conditions also affected water activity of jaggery significantly ($p\leq0.01$).

The changes in total viable count of jaggery samples during storage of 18 weeks are presented in table 3. The initial TVC in terms of Colony Forming Units per gram (cfu/g) in ambient sample and in the treatments T1 (U/O), T2 (U/P), T3 (C/O), T4 (C/P), T5 (U/V), T6 (C/V) were $2.16x10^3$, $2.04x10^3$, $1.98x10^3$, $2.34\ x10^3$, $2.17x10^3$, $2.45x10^3$ and $2.04\ x10^3$, respectively. It was observed from the storage study that total viable count followed increasing trend during 18 weeks of storage period in all the treatments. At the end of the storage weeks, the

Table 3: Effect of storage on total viable count of jaggery samples

Storage	Amb	U/O	C/O	U/P	C/P	U/V	C/V
0 week	$2.16\times10^3\pm3$	$2.04\times10^3\pm2.08$	$1.98\times10^3\pm0.64$	$2.34\times10^3\pm1.18$	$2.17\times10^3\pm1.03$	$2.45\times10^3\pm0.94$	$2.04\times10^3\pm0.88$
3 weeks	$2.76\times10^3\pm0.84$	$2.54\times10^3\pm0.80$	$2.36\times10^3\pm0.77$	$3.67\times10^3\pm0.74$	$3.42\times10^3\pm0.72$	$2.73\times10^3\pm0.69$	$2.57\times10^3\pm0.68$
6 weeks	$3.89\times10^3\pm0.66$	$3.34\times10^3\pm0.64$	$2.97\times10^3\pm0.63$	$4.78\times10^3\pm0.62$	$4.13\times10^3\pm0.60$	$3.84\times10^3\pm0.59$	$3.67\times10^3\pm0.58$
9 weeks	$4.21\times10^3\pm0.57$	$3.89\times10^3\pm0.56$	$3.54\times10^3\pm0.56$	-	-	$4.26\times10^3\pm0.58$	$4.19\times10^3\pm0.57$
12 weeks	$5.32\times10^3\pm0.56$	$4.98\times10^3\pm0.55$	$3.76\times10^3\pm0.54$	-	-	$4.92\times10^3\pm0.55$	$4.86\times10^3\pm0.54$
15 weeks	$5.67\times10^3\pm0.53$	$5.43\times10^3\pm0.53$	$4.32\times10^3\pm0.52$	-	-	$5.34\times10^3\pm0.54$	$5.02\times10^3\pm0.53$
18 weeks	$6.24\times10^3\pm0.56$	$5.94\times10^3\pm0.53$	$5..16\times10^3\pm0.52$	-	-	$5.86\times10^3\pm0.52$	$5.67\times10^3\pm0.36$
F value	**	**	**	**	**	**	**

Mean value ± S.D
Values shown in table average of triplicates
-: Not determined further as sample was unacceptable due to liquefaction
* * Significant at 1% level of significance

Table 4: Variations in temperature and Relative Humidity of environment during study

No. of week under study	Month and Date	Max. Temp (C°)	Min. Temp (C°)	Relative Humidity (%)
1	Jan-Feb 29-04	22.8	5.2	68.5
2	Feb 05-11	22.5	9.7	74.5
3	Feb 12-18	23.6	8.3	72
4	Feb 19-25	24.4	10.1	67.5
5	Feb-Mar 26-04	28.4	12.5	70.5
6	Mar 05-11	28.7	12.5	64.5
7	Mar 12-18	30.4	13.2	61
8	Mar 19-25	33.8	16.1	60.5
9	Mar-Apr 26-01	35.9	16.0	52
10	Apr 02-08	37.4	15.0	48
11	Apr 09-15	40.6	17.2	41
12	Apr 16-22	39.6	23.7	40.5
13	Apr 23-29	39.3	19.0	37.5
14	Apr-May 30-06	36.9	23.2	48.5
15	May 07-13	36.0	19.8	56
16	May 14-20	40.6	24.1	40.5
17	May 22-28	39.0	25.8	44
18	May-June 29-04	38.01	27.7	48.1

maximum colonies were $6.24x10^3$, found in control sample (Amb) and minimum colonies found were $5.16x10^3$, in jiggery samples with edible coating and vacuum packaging (C/V). This shows that coating the jaggery samples with WPC based edible coating and then packaging in vacuum may help to reduce the deterioration of jaggery samples by micro-organisms up to some extent. Coating of jaggery samples with edible coating significantly ($p\leq0.01$) affected microbial counts as shown by marked difference in TVC obtained for uncoated and coated samples. A significant ($p\leq0.01$) difference in TVC was observed in all the packaging treatments and storage conditions as compared with TVC of jiggery stored under ambient conditions. Narain and Singh (1983) also reported that microbiological deterioration is one of the major problems associated with jaggery storage. He also stated that moisture absorption during storage may aggravate the problem of microbial spoilage. Khanna and Chakravarti (2009) observed that highly humid conditions prevailing during storage leads to microbial spoilage of jaggery. Uppal and Sharma (1998) concluded that storing the jaggery in air tight glass containers completely check the microbial spoilage during storage.

CONCLUSION

Jaggery would be a healthier alternative for sweetness due to absence of fat and higher mineral content. However it has problems related to keeping quality. The main problems are running-off (liquefaction) of jaggery during rainy season and deterioration of color during storage. These problems are because of absorption of moisture and microbial attack (Kunte, 1952). These problems could be overcome by applying WPC based edible coating on jaggery then packaging it under vacuum and storing it at controlled conditions of

temperature and relative humidity.

Abbreviations

LDPE - Low density polyethylene
WPC - Whey Protein Concentrate
AOAC - Association of Official Analytical Chemists
ANOVA - Analysis of Variance

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