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Accelerated storage and shelf-life of whey protein concentrate and gum arabic coated solid jaggery

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SUMMARY :

Sugarcane jaggery samples (25 g) were coated with the optimized concentration of edible coating (0.5% WPC and 0.5% gum arabic) and placed in LDPE, HDPE and PP pouches packed thenine pouches (three LDPE pouches, three HDPE and three PP pouches) with MAP machine. The samples were analyzed for important physico-chemical characteristics *viz.*, sucrose, reducing sugars, colour, Hardness and moisture content. The whey protein coated solid jaggery stored in PP packets under vacuum was found to be better *i.e.*, low increase in reducing sugars and decrease in non-reducing sugars, as compared to the samples packed in LDPE, HDPE under vacuum and MAP at storage temperature of 25°C. Accelerated storage studies were conducted for the sugarcane solid jaggery samples (50 g) coated with optimized concentration of edible coating (0.5% concentration of both protein (WPC) and polysaccharide (gum arabic) based) placed in LDPE, HDPE and PP pouches with vacuum and MAP packing and all these pouches were placed in the desiccator at 90% RH and this desiccator was kept in incubator at 45p C. The maximum predicted storage life *i.e.* 255.44 days was obtained in the 0.5% WPCedible coated solid jaggery packed in LDPE with vacuum packaging machine.

KEY WORDS : Jaggery, Edible coating, Whey protein, Gum arabic, Accelerated storage studies

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Jaggery production in our country is a traditionally labour intensive cottage industry mostly confined to rural areas. Jaggery is an eco- friendly nutritive sweetener and meets about 40 per cent demand of sweeteners in the country. Jaggery has been in use as energy food and sweetening base for a number of preparations since time immemorial. Jaggery contains 70-85 per cent sucrose, 10-15 per cent reducing sugars, 1-2 per cent minerals. In Ayurveda, jaggery is considered to be the best due to its mechanical properties like cooling, diluretic, aperient, aphaodisiac and also it acts as lactogenic and cardiac tonic. In India, production of jaggery starts from October and continues upto May, depending on the location. The total jaggery is 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. Edible films and coatings has been successfully used in various food applications e.g., in maintaining purity of fruits, providing functionality (e.g. glaze to chocolate), controlling adhesion, cohesion, barrier properties, extending shelf-life and providing mechanical integrity to the product.The quality of the product on storage is to a great extent relied on upon the water activity of the product (McMinn and Magee, 1999; Singh and Singh, 1996 and Wang and Brennan, 1991) which thus relies on upon the moisture content and temperature of storage. Moisture sorption behaviour of solid jaggery could be an important data on its drying behaviour and storage quality.

Edible films and coatings may extend the shelf-life of jaggery by providing a semi-permeable barrier to gases and water vapour. This barrier would reduce diffusion of gases, enzymatic browning and the loss of water from the product. However, this technology is not developed for protection of jaggery from spoilage due to lack of detailed study.

The objective of this study was to determine the physico-chemical properties of the whey protein concentrate and gum arabic coated solid jaggery cubes namely, water activity, moisture content, sucrose, reducing sugar, colour and hardness. Accelerated storage studies were carried out for the sugarcane solid jaggery samples (50 g) coated with optimized concentration of edible coating (0.5% concentration of both protein (WPC) and polysaccharide (gum arabic) based) placed in LDPE, HDPE and PP pouches with vacuum and MAP packing and all these pouches were placed in the desiccator at 90% RH and this desiccator was placed in incubator at 45^{o}C.

Devi *et al.* (2016) studied the shelf-life of the vacuum puffed honey powder at accelerated storage environment (90% relative humidity and 36°C) by determining the sticky-point moisture content as the critical parameter of the honey powder. Shelf-life of the honey powder was predicted to be 222 days when the powder was packaged in aluminium foil-laminated polyethylene pouches with permeability value of 5.427x10^{-8} kg/m^{2}//day/Pa whereas the actual shelf-life of honey powder was experimentally determined as 189 days.

Ramachandra and Rao (2011) predicted the shelf-life of the *Aloe vera* gel powder, produced through dehumidified air drying of *Aloe vera* gel at optimized conditions of temperature, relative humidity and air velocity of 64°C, 18 per cent and 0.8 m.s^{-1}, respectively, on the basis of free flowness of product under accelerated storage condition (38±1°C, 90± 1% relative humidity) and was calculated to be 33.87, 42.58 and 51.05 days in biaxially oriented polypropylene (BOPP), polypropylene (PP) and laminated aluminum foil (AF), respectively.

Jaya and Das (2005) studied the shelf-life of the Vacuum-dried mango powder was produced from mango pulp. The mango powder was packed in aluminum foil-laminated pouches and stored in an accelerated storage environment maintained at 90 per cent relative humidity (RH) and 38±2C. The sticky-point moisture content at 38±2C was considered as the maximum moisture content to which the mango powder would remain stable. The shelf-life of the powder predicted from this consideration and the Guggenheim-Anderson-de Boer (GAB) model for the water activity moisture content relationship was 114.68 days, whereas the actual shelf-life was 105 days.

EXPERIMENTAL METHODS

Preparation of sample :

Freshly prepared jaggery cubes with dimensions 25×25×25 mm moulded by using the metal frame (developed to obtain the jaggery cubes of desired dimension), made from sugarcane juice (variety 93 A 145), with an initial moisture content of 10% (db), was taken for study. Edible coatings (0.5% of WPC and gum arabic) are prepared by dissolving the edible coating material in 100ml distilled water and mixed thoroughly to form uniform solution. The solution was denatured at 90ºC on water bath for 30 minutes to provide functionality to edible film. The solution was cool down to room temperature in chilled water. 5 per cent glycerol was added to solution as plasticizer and mixed thoroughly. Then, the prepared solution was again reheated at 50ºC for 10 minutes, then cooled to room temperature (Mishra *et al*., 2016). The prepared edible coatings were applied on solid jaggery cubes by dipping method.

Determinations of physico-chemical characteristics of solid jaggery :

Water activity:

The water activity of edible coated solid jaggery samples was measured by using HygroLab C1 Bench-Top Indicator, Rotronic AG Bassersdorf, Switzerland. The sample was placed in the a_w probe and the reading will be showed in the display.

Colour :

For the measurement of colour of samples combination of digital camera, computer and Adobe Photoshop 7.0 software provides a less expensive and more versatile way to determine colour parameters of food products than traditional colour measuring equipment's and also good colour of sample depends upon the intensity of light and distance between sample and camera. This colour measuring technique involves setting up a lighting system, high resolution digital camera to capture images of food samples reported by Spyridon *et al.* (2000).

Madhod:

The samples was placed under the source of light at minimum distance and intensity of light over the sample should be uniform for good quality colour. Digital camera (Sony 7.2 mega pixels) was used to capture the image of sample. The L*, a*, b* values of samples were measured by using Adobe Photoshop 7.0 software. To obtain lightness, a and b values obtained from the Histogram window to L*, a* b* following formulas were used.

$$\mathbf{L^* = \frac{Lightness}{250} x100} \quad .....(1)$$

$$\mathbf{a^* = \frac{240\,x\,a}{255} - 120} \quad .....(2)$$

$$\mathbf{b^* = \frac{240\,x\,b}{255} - 120} \quad ....(3)$$

Colour difference (ΔE) indicates the degree of overall colour change of a sample in comparison to colour values of an standard sample having colour values of L*, a*, and b*.The colours of the samples represents in terms of L (whiteness/darkness), a (redness/greenness), b (yellowness/blueness). Colour difference was calculated using Eq. 4.

$$\mathbf{\Delta E = [(L - L^*) + (a - a^*) + (b - b^*)^2]^{0.5}} \quad ....(4)$$

Hardness:

The texture attribute of hardness or degree of softening was measured by determining the maximum penetration force for stored edible coated jaggery samples. A texture analyser model TA XD pluswas used to measure the hardness in terms of force (Newton) required for penetration of probe (P/75) into the sample using the following parameters. A cylindrical probe of 5mm diameter was used for the penetration into the samples.

Non-reducing sugars (*sucrose*) :

It was determined according to official method of International commission for uniform method of sugar analysis (ICUMSA, 1964).

Reducing sugars :

It was determined according to Lane and Eynon's volumetric method (Rangana, 1987).

Permeability test for packaging material :

Determination of water vapour permeability is gravimetric analysis. Dry silica gel in in the packaging material cap from packaging material changes own weight, because silica gel receive water vapour through packaging material in environment with known relative humidity and temperature. Water vapour permeability of low-density polyethylene (LDPE), High density polyethylene (HDPE) and polypropylene (PP) pouches were investigated. The thickness and area of the pouches were shown in the Table A.

Table A : The thickness and area of the packaging materials

Sr. No.	Material	Thickness (micron)	Area (m^2)
1.	LDPE	87.5	0.03375
2.	HDPE	40.0	0.03375
3.	PP	37.5	0.03225

Method:

All three packaging material pouches (triplicate) were filled with approximately equal weight of desiccants (Silica gel). After filling with desiccant pouches were properly sealed on heat sealing machine. Then all three pouches with desiccants kept in BOD Incubator at 38±2°C temperature and 90±1% relative humidity.After that weight change reading was taken every day all three pouches. Day by day we noticed that weight of pouches is increasing in some cases its slightly decreasing. After thirteen days we noticed that there was no weight change of pouches. The cumulative moisture gain with time by silica gel kept in three pouches (LDPE, HDPE and PP) was noted down and made statistical analysis. The analytical data kept in the following equations and we calculated the water vapour transmission rate and water vapour permeability of the three pouches.The saturated vapour pressure (P) of water at 40 ^{o}C is 7375.02 Pa.

Water vapour transmission rate (kg/day*m^{2})

$$= \frac{\text{Weight gain (kg/day)}}{\text{Area of } (m^2) \text{ x 2 (sides) x No. of days}} \quad .....(5)$$

Permeance (kg/day*m^{2}*Pa)

$$= \frac{\text{Water vapour transmission rate (kg/day * } m^2)}{\text{Saturated vapour pressure (p) of water (pa)}} \quad .....(6)$$

Water vapour permeability

(Kg*micron/day*m^{2}*Pa)=Permeance ×Thickness .....(7)

Accelerated storage of edible coated solid jaggery:

Accelerated shelf-life studies are conducted by changing the storage conditions to fasten the deteriorative processes that occur during storage. In confections, elevated temperatures and humidities are often used to enhance product degradation in accelerated shelf-life tests. A product with a one-year shelf-life may be evaluated under accelerated storage conditions within perhaps a month in certain circumstances (Ergun *et al.*, 2010). Twenty five grams of edible coated (0.5% concentration of WPC and gum arabic) solid jaggery with an initial moisture content Xi= 0.010kg water/kg dry solids was packed in 9×6 inches (LDPE, HDPE) pouches, 8×6 inches PP pouches and placed in an environment maintained at 90% RH and 38 ±2^{o}C. Nine pouches (three LDPE, three HDPE and three PP pouches) were filled with 0.5 per cent concentration of WPC coated solid jaggery and packed with modified atmosphere packaging machine. Nine pouches (three LDPE, three HDPE and three PP pouches) were filled with 0.5 per cent concentration of WPC coated solid jaggery and packed with vacuum packaging machine. Nine pouches (three LDPE, three HDPE and three PP pouches) were filled with 0.5 per cent concentration of gum arabic coated solid jaggery and packed with modified atmosphere packaging machine. Nine pouches (three LDPE, three HDPE and three PP pouches) were filled with 0.5 per cent concentration of gum arabic coated solid jaggery and packed with vacuum packaging machine. Total thirty six such Pouches were prepared, and after intervals of 10 days, one of the pouches was removed from the control environment and its contents analysed for moisture content X (kg water/kg dry solids).

Moisture gain and storage life prediction :

The rate of change of moisture content *dx/d*q of the powder with storage time θ is expressed as:

$$X_s \frac{dx}{d\theta} = KA_p \, (Rhp^* - a_w p^*) \quad ....(8)$$

where, Xs (kg) is the dry weight of the edible coated solid jaggery inside the pouch; p^* (Pa) is the saturation vapour pressure of water at the temperature T (^{o}C) of storage; Rh is the relative humidity of the storage environment; K (kg water/m^{2}/day/Pa) is the permeability of the packaging material; Ap (m^{2}) is the surface area of the packaging material through which water vapour permeates; a_w is the water activity of the edible coated jaggery at T (^{o}C) and X (kg water/kg·dry·solids) is the moisture content of the edible coated jaggery after θ days of storage time. The integration of Eq. (8) with initial and critical moisture content value is used to predict the shelf-life of the edible coated jaggery and the storage-life can be expressed as:

$$\theta = X_s \, (X_c - X_i) / KA_p (Rhp^* - a_w p^*) \quad ....(9)$$

EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Physico-chemical characteristics of solid jaggery:

Physico-chemical characteristics of solid jaggery without and with edible coating under MAP and Vacuum packed LDPE, HDPE and PP packets:

The freshly prepared solid jaggery cubes (25g) without edible coating and with edible coating (0.5% concentration of whey protein concentrate and 0.5% concentration gum arabic) samples packed in LDPE, HDPE and PP with MAP and Vacuum packaging machine wasanalyzed for its physico-chemical characteristics *i.e.*, Moisture content, water activity, hardness, colour, sucrose and reducing sugars with respect to storage period, temperature and packaging material.

Water activity:

The changes in the water activity of solid jaggery without and with edible coating at temperatures of 25°C during storage period under MAP and Vacuum packed LDPE, HDPE and PP packets are shown in the Fig. 2. It was found that there was significant differences of a_w for all the samples. The experimental data revealed that the initial water activity of the jaggery samples ranges from 0.373 to 0.384. Water activity of the jaggery samples follows increasing trend as storage period increases. After completion of storage period, the highest value of water activity *i.e.* 0.421 was found in the solid jaggery sample without edible coating (control) and the lowest value of water activity *i.e.* 0.387 was found in the solid jaggery sample coated with 0.5 per cent concentration WPC packed in PP pouch with vacuum condition. Comparing the awvalues to the moisture values, it was found that the greater the moisture, the higher the a_w, which agrees with what was reported by Verma and Maharaj (1990) for block panela.

Sucrose:

The experimental changes in non-reducing sugar (sucrose) content of solid jaggery without and with edible coating at temperatures of 25°C during storage period under MAP and Vacuum packed LDPE, HDPE and PP packets are shown in the Fig. 3. The initial sucrose contents of the jaggery sample without coating and with WPC, gum arabic coated jaggery samples were 82.40, 82.29 and 82.25, respectively. There was no significant changes in the sucrose content of the jaggery samples throughout the storage period. It was observed that in the vacuum packed jaggery sample there was less decrease in the sucrose content as compare to the MAP packaging and the WPC coated solid jaggery sample in PP pouch packed with vacuum packing shows the better result as compared to the other samples. Shinde *et al.* (1981) opined that polyethylene of any form and colour prevented inversion of non-reducing sugar. According to the findings of Uppal and Sharma (1999), there was no difference in sucrose content of jaggery of glass and plastic containers. Singh (1998) reported less reduction in sucrose content of jaggery (3.2%-3.6%) kept in plastic containers.

Reducing sugars:

The changes in reducing sugar content of solid jaggery without and with edible coating at temperatures of 25°C during storage period under MAP and Vacuum packed LDPE, HDPE and PP packets are shown in the Fig. 4. It was observed that reducing sugar increased as the storage period increased, but there was least increasing in coated samples as compared to uncoated samples. In the solid jaggery sample without edible coating, there was significant increase in the reducing sugars from 6.84 to 7.11 for the storage period. The data revealed that there was less increase in the reducing sugars in the 0.5 per cent concentration of WPC coated solid jaggery samples packed in PP pouches with vacuum packing throughout

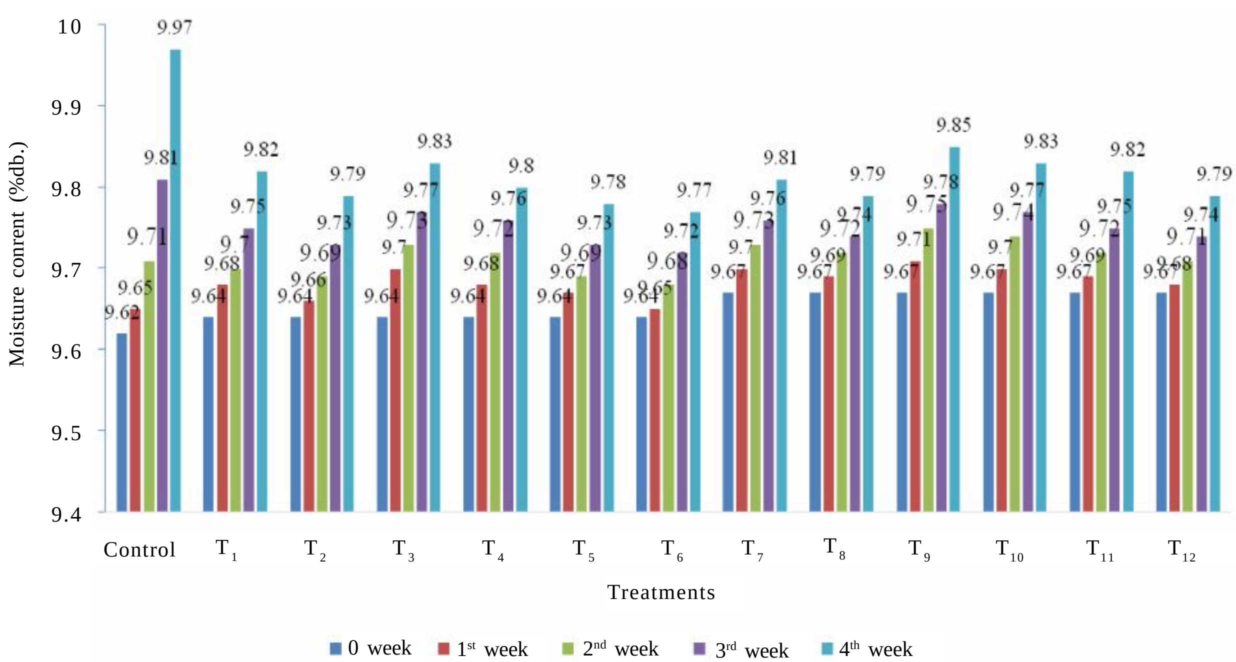

Fig. 1 : Changes in moisture content of edible coated jaggery stored in different packaging material at 25°C temperature

storage period from 6.87 to 7.00 as compared to the other samples. The data also revealed that jaggery sample coated with 0.5 per cent WPC gives less increase in the reducing sugar as compared to 0.5 per cent gum arabic coated sample and there was less increasing in the reducing sugars packed in PP pouches followed by LDPE and HDPE. The increase in reducing sugar content in jaggery may be due to inversion

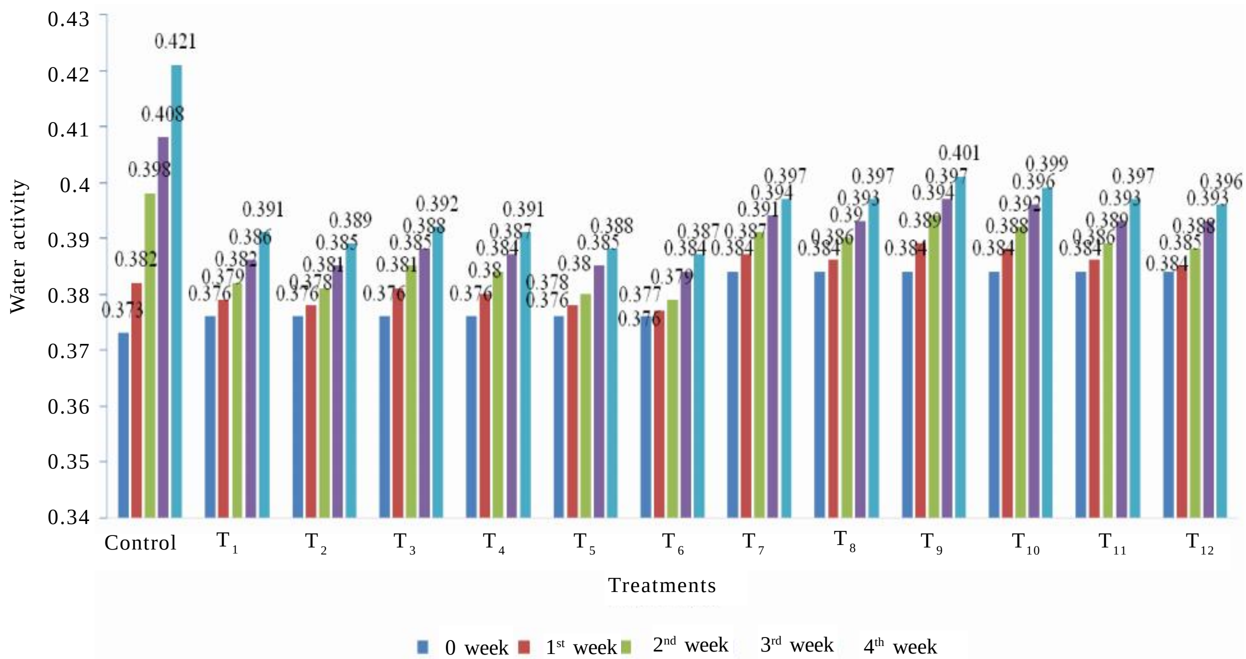

Fig. 2 : Changes in water activity of edible coated jaggery stored in different packaging material at 25°C temperature

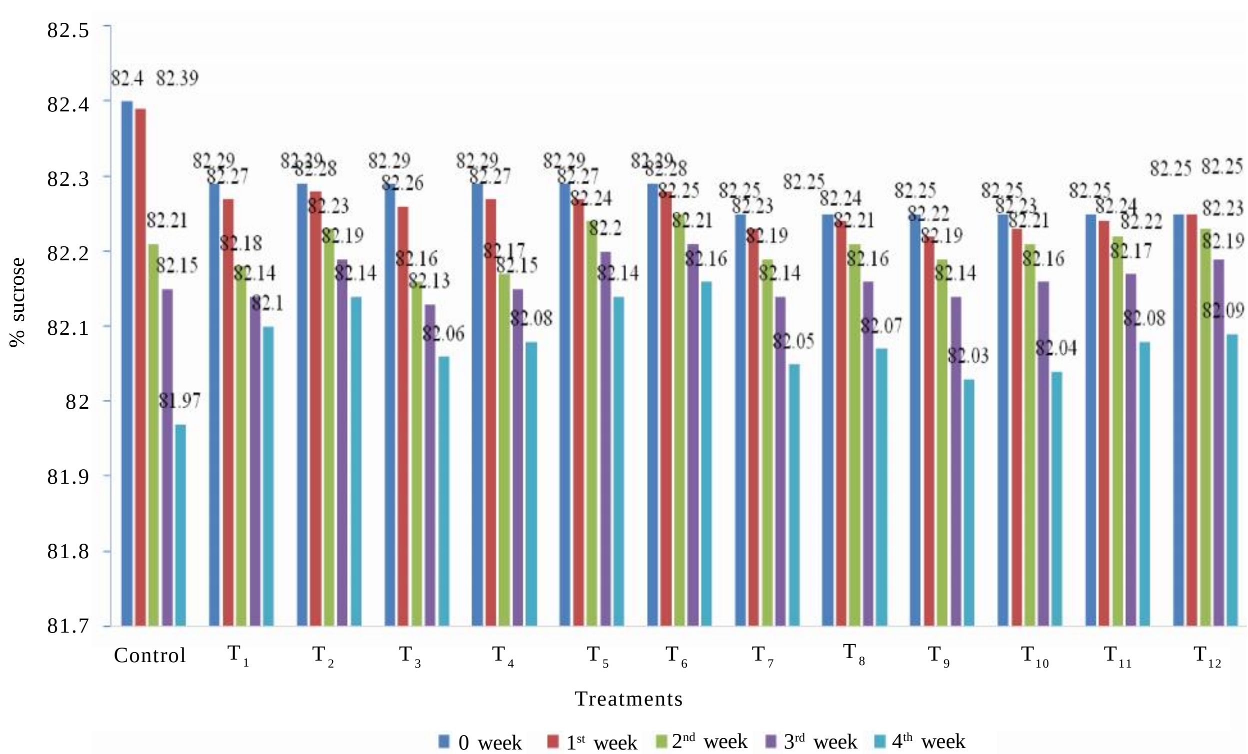

Fig. 3: Changes in sucrose (% db.) of edible coated jaggery stored in different packaging material at 25°C temperature

of sucrose into glucose and fructose. Shinde *et al.* (1983) reported that jaggery wrapped in polyethene film showedno inversion of non-reducing sugars during storage and there was almost no change in the reducing sugar values. The decrease in sucrose or the increase in reducing sugars was more or less in accordance with the increase in moisture and it can be inferred that high absorption of moisture creates conditions for inversion (Mandal *et al.*, 2006).

Colour:

The changes in colour of solid jaggery without and with edible coating at temperatures of 25°C during storage period under MAP and vacuum packed LDPE, HDPE and PP packets are shown in the Fig. 5. The results revealed that there was a significant changes in the colour of the uncoated jaggery and there was no significant difference in the colour of the coated jaggery. 0.5 per cent WPC coated jaggery cubes packed in HDPE pouches with vacuum condition shows less change in the colour followed by 0.5 per cent WPC coated jaggery cubes packed in LDPE pouches with MAP packing and 0.5 per cent gum arabic coated jaggery cubes packed in HDPE pouches with MAP packing throughout the storage period. Uppal and Sharma (1999) observed that there was no difference in quality parameters of jaggery

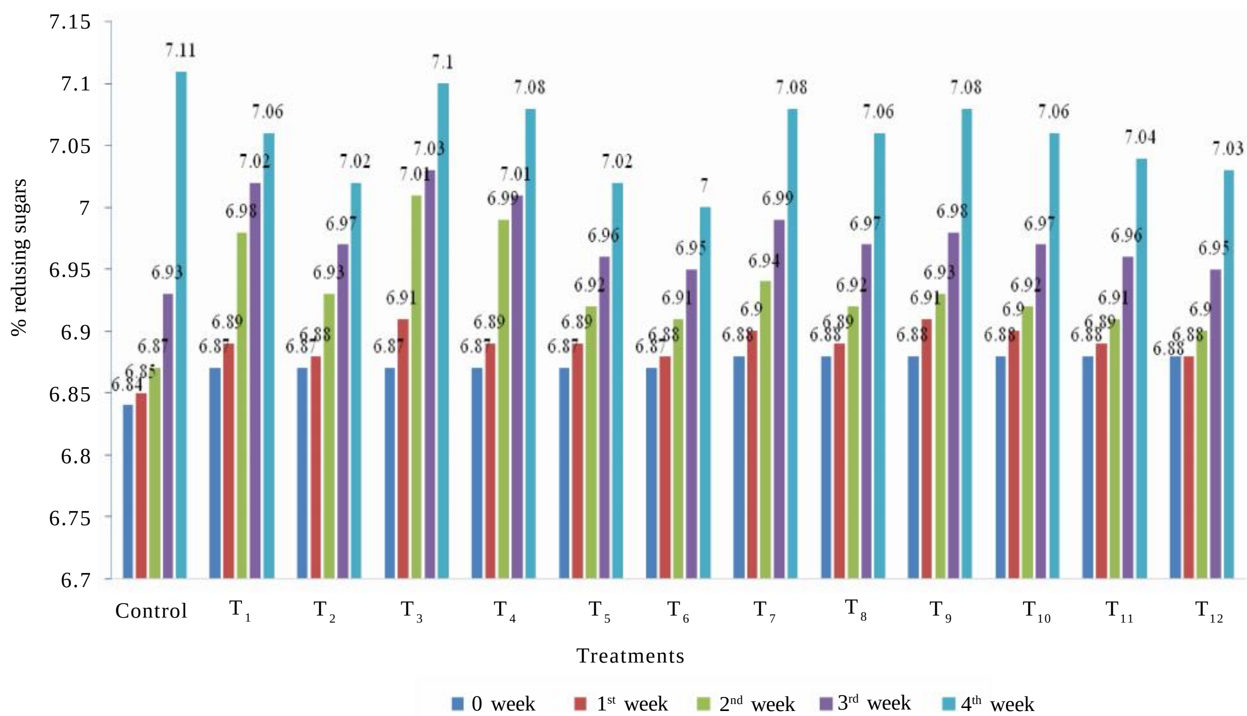

Fig. 4: Changes in reducing sugar of edible coated jaggery stored in different packaging material at 25°C temperature

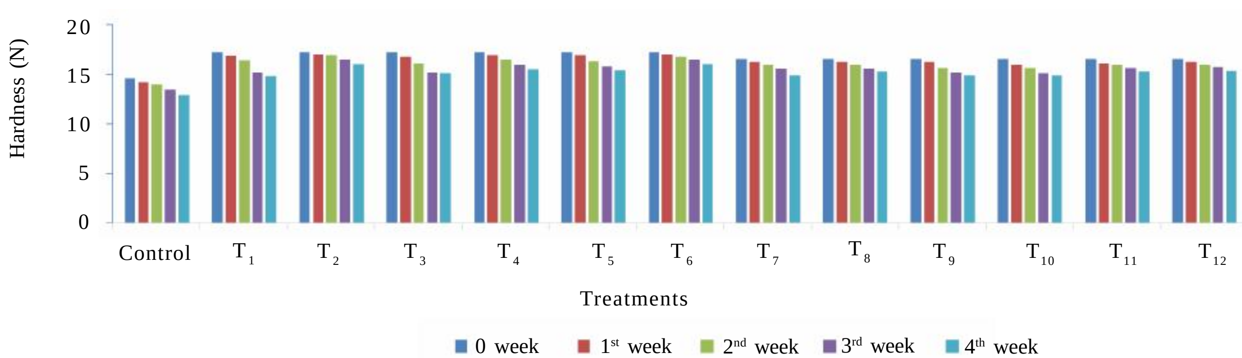

Fig. 5: Changes in hardness of edible coated jaggery stored in different packaging material at 25°C temperature

stored in airtight glass and plastic containers except the colour, which was better in airtight glass containers.

Hardness:

The changes in hardness of solid jaggery without and with edible coating at temperatures of 25°C during storage period under MAP and Vacuum packed LDPE, HDPE and PP packets are shown in the Fig. 6. The initial hardness in terms of force required in Newton (N) to compress the sample completely was in the range of 14.627 to 17.269 in all the treatment. The data revealed that the hardness of the uncoated, WPC coated and gum arabic coated solid jaggery samples ranges from 14.627 to 12.965N, 17.269 to 14.875 and 16.578 to 14.971, respectively. It was observed from the storage study that hardness followed the decreasing trend throughout the storage period. This can be observed that coating of jaggery samples could have helped in retaining the desirable moisture upto an extent for soft texture while in control lead to an excessive moisture loss from leading to undesirable dry, brittle and hard texture. WPC coated and packed in PP pouch with vacuum package gives the less decrease in the hardness as compared to the other samples. The highest decrease in the hardness was observed in the jaggery sample without coating. This can be observed coating of jaggery samples could help upto some extent in retaining the texture of jaggery.

Properties of packaging materials:

Fig. 7 showed cumulative moisture gain with time by silica gel kept in three pouches (LDPE, HDPE and pp) at 38±2°C temperature and 90±1% relative humidity. Calculated value of slope of the best fit straight lines of LDPE, HDPE and PP were 0.0001 kg.day^{-1}, 0.0005 kg. day^{-1} and 0.0006 kg. day^{-1}, respectively. The surface area (A) for LDPE and HDPE was 0.03375m^2 and for PP 0.03225 m^2. The saturated vapour pressure (P) of water at 40°C is 7375.02 Pa. by putting these values in the Eq.

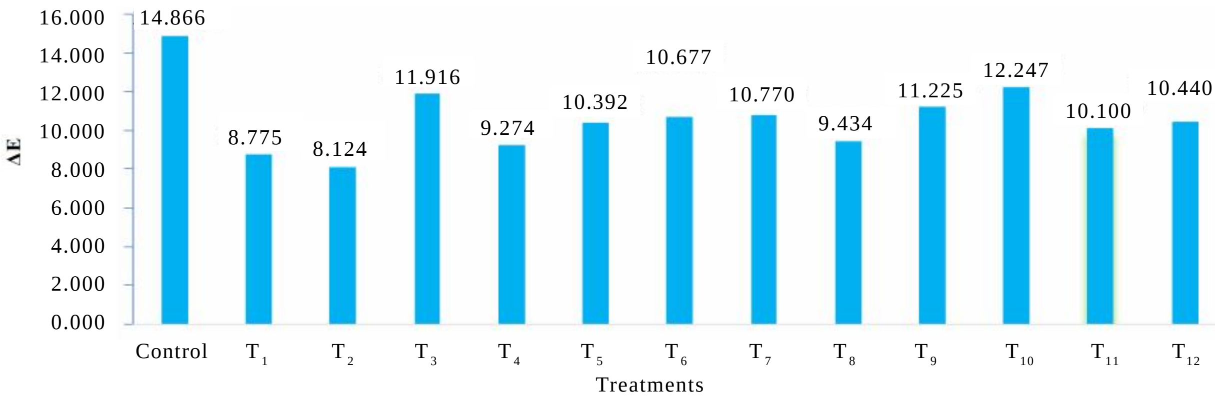

Fig. 6: Changes in colour of edible coated jaggery stored in different packaging material at 25°C temperature

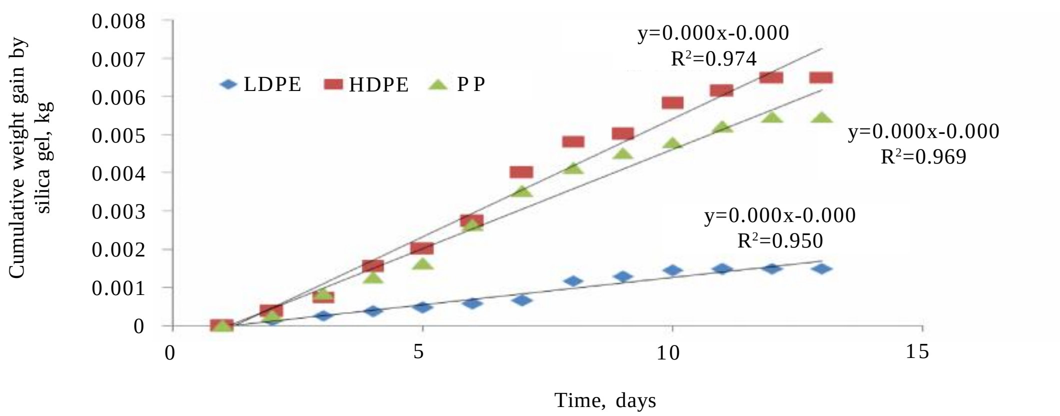

Fig. 7: Cumulative moisture gain by silica gel through different packaging materials with time of storage in controlled environment

(7). We determined the values of water vapour transmission rates and permeability of selected three packaging materials and were presented in the Table 1. Table 1 reveals that low density polyethylene (LDPE) had lowest permeability followed by polypropylene (PP) and high density poly ethylene (HDPE).

Determination of shelf-life of edible coated jaggery during accelerated storage:

The initial moisture contents Xi of the 0.5 per cent concentrated WPC and gum arabicedible coated solid jaggery were 0.00964 and 0.00967 kg water/kg dry solids, respectively and the critical moisture content Xc of the 0.5 per cent concentrated WPC and gum arabicedible coated solid jaggery placed in the different packaging material when stickiness started were given in the Table 2. Substituting saturation vapour pressure of water at 40°C from steam table as 7.37502kPa, the relative humidity (Rh) of the storage environment as 0.9, The surface area (A) for LDPE and HDPE was 0.03375m^2 and for PP 0.03225 m^2 and water vapour permeability of the pouch material as LDPE, HDPE and PP were 1.352×10^{-8} kg water/day $\times m^2\times$pa, 3.708×10^{-8} kg water/day$\times m^2\times$pa and 3.032×10^{-8} kg water/day$\times m^2\times$pa and the amount of dry solids in 50 g of both WPC and gum arabicedible coated solid jaggery presented in Table 2 in Eq. (9), the numerical solution of Eq. (8) resulted in the graphical relationship between the time of storage and the moisture content of the honey powder These findings are in similar line with various previous research outcomes. It was observed that mango and watermelon juice powder showed stickiness and significant caking at 8.9% (db) and 5% (db) moisture content, respectively (Jaya and Das, 2005 and Arya *et al*.,1986). Experiments also revealed higher storage life of vacuum puffed honey powder in compared to 2 months and 105 days experimental shelf-life of watermelon and mango juice powder, respectively (Jaya and Das 2005 and Arya *et al*.,1986).

The predicted storage life of solid jaggery with edible coating packed under MAP and Vacuum condition in LDPE, HDPE and PP packets were presented in the Table 2. The minimum predicted storage life *i.e.* 156.37 days was observed in the 0.5 per cent concentrated gum arabicedible coated solid jaggery packed in HDPE with MAP packaging machine and the maximum predicted storage life *i.e.* 255.44 days was obtained in the 0.5 per cent WPCedible coated solid jaggery packed in LDPE with vacuum packaging machine. The storage life of edible coated jaggery was maximum in LDPE with

Table 1: Specifications of packaging materials used in the storage study

Sr.No.	Material	Thickness (micron)	Area (m^2)	WVTR (kg water/day×m^2)	Permeability (kg water/day×m^2×pa)
1.	LDPE	87.5	0.03375	0.00011396	0.000001352
2.	HDPE	40	0.03375	0.00068376	3.7085E-06
3.	PP	37.5	0.03225	0.0005963	3.03204E-06

Table 2: Shelf-life of edible coated jaggery during accelerated storage

Sr.No.	Treatments	Initial weight g	Dry weight, kg	$X_{i,}$ (kg water/kg dry solids)	X_c (kg water/kg dry solids)	Predicted storage life, days
1.	T_1	49.625	0.04914	0.00964	0.01814	237.022
2.	T_2	50.234	0.04974	0.00964	0.01869	255.443
3.	T_3	49.547	0.04906	0.00964	0.02588	164.729
4.	T_4	50.008	0.04952	0.00964	0.02683	175.968
5.	T_5	47.128	0.04667	0.00964	0.02502	189.961
6.	T_6	49.269	0.04879	0.00964	0.02461	193.326
7.	T_7	50.274	0.04970	0.00967	0.0177	231.202
8.	T_8	50.048	0.04956	0.00967	0.01828	245.823
9.	T_9	49.974	0.04949	0.00967	0.02472	156.376
10.	T_{10}	48.634	0.04816	0.00967	0.02627	167.843
11.	T_{11}	47.857	0.04739	0.00967	0.02451	188.960
12.	T_{12}	49.028	0.04855	0.00967	0.02429	190.707

vacuum packing followed by PP and HDPE.

Conclusion:

The water activity, moisture content, reducing sugars of edible coated solid jaggery shows the increasing trend whereas, the sucrose content and hardness of the edible coated solid jaggery shows decreasing trend throughout the storage period. The coated solid jaggery shows better results as compared to uncoated solid jaggery. The water vapour permeability of LDPE, HDPE and PP pouches was determined and the values were 1.352×10^{-8}, 3.708×10^{-8} and 3.032×10^{-8}kg water/day×m²×pa, respectively. The data revealed that the low density polyethylene (LDPE) had lowest permeability followed by polypropylene (PP) and high density poly ethylene (HDPE).The predicted storage life of solid jaggery with edible coating packed under MAP and Vacuum condition in LDPE, HDPE and PP packets wereinvestigated. The minimum predicted storage life *i.e.* 156.37 days was observed in the 0.5 per cent concentrated gum arabicedible coated solid jaggery packed in HDPE with MAP packaging machine and the maximum predicted storage life *i.e.* 255.44 days was obtained in the 0.5 per cent WPCedible coated solid jaggery packed in LDPE with vacuum packaging machine. The storage life of edible coated jaggery was maximum in LDPE with vacuum packing followed by PP and HDPE.

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