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Osmotic Dehydration of Aloe-vera Gel Discs

SHAGHAF KAUKAB[1*], PRATIBHA DEVI SHARMA[2] AND ALKA MISHRA[3]

ABSTRACT

Aloe-vera is a perennial plant with various pharmaceutical properties. The potential use of Aloe-vera products often involves some type of processing, like heating, dehydration and grinding. Aloe-vera gel discs were osmotically dehydrated at different temperatures (30°, 40° and 50° C) and different sugar concentrations (30°, 40° and 50° Brix). The best temperature and concentration combination obtained were 50°C and 40° Brix, respectively with maximum moisture loss and minimum solute gain. The osmotically dehydrated samples were further dried and compared with raw dried samples. The osmotically dehydrated sample dried to lower moisture content compared to raw sample. The rehydration ratio, colour retention and organoleptic properties of osmotic dehydrated samples were far better than raw dried samples. Osmotic dehydration can be used as an effective processing technique for Aloe-vera without loss in its quality and functional activity.

Keywords: Sugar concentration, Drying, Rehydration ratio, Moisture content, Colour

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INTRODUCTION

Aloe-vera (*Aloe barbadensis* Miller) is a perennial plant of liliacea family originated in tropical Africa and now cultivated across the globe in warm climatic areas of Asia, Europe, and America. In India Aloe-vera has been referred to as 'Ghrit kumari' in ayurvedic treatments. Aloe-vera is as old as civilization and throughout history it has been used as a popular folk medicine popularly known as miracle plant. From being an antiseptic, anti- inflammatory and a cure for heart burns, to being a beauty aid and nourishes health, this ancient Indian herb has it all (Pisalkar *et al*., 2014). Known for centuries for its unique medicinal properties, it has been rediscovered, recognized and benefited in the last few years (Jadav *et al*., 2020). It is believed to be effective in treating stomach ailments, gastrointestinal problems, skin diseases, constipation, for radiation injury, for its anti-inflammatory effect, for wound healing and burns, as an anti-ulcer and diabetes (Sánchez *et al*., 2020).

Because of its use in the food, aloe vera gel made from the plant's leaf pulp has become a huge industry globally. The possible use of Aloe-vera products frequently involves some form of processing, such as filleting, dehydration, heating, and grinding (Scala *et al*., 2013). Aloe products unfortunately contain extremely little or almost no active components due to faulty preparation. Unfortunately, because of improper processing procedure aloe products contain very little or virtually no active ingredients (Pisalkar *et al*., 2011). Femenia *et al*. (2003) evaluated the main effects of drying temperature on the physic-chemical properties of the main type of polysaccharide, present in Aloe-vera parenchyma. They concluded that importance of the physico-chemical modification detected in dehydration of Aloe-vera parenchyma depended on the temperature used during drying process.

For these reasons, it is necessary that the leaf be processed with the aim of retaining every bioactive component. Osmotic dehydration has been reported to be effective in retention of nutritional and functional properties of the food as well as increasing the shelf life quality of the final product with reduction in drying time. Interest in using low temperature, osmotic dehydration to obtain potential ingredients, as it maintains the constituents in an unaltered and active form. The aim of this work was to analyze the osmotic dehydration of Aloe-vera as a function of type of solution, solute concentration and temperature with the objective of evaluating the effect of solute concentration and temperature on water loss and solid gain of Aloe-vera gel discs and the effect of osmotic pretreatment on drying and various other quality characteristics.

MATERIALS AND METHODS

Raw materials and sample preparation

Fresh and healthy Aloe-vera leaves (*Aloe barbadensis* Miller) were obtained from the Herbal Garden of Medicinal and Aromatic Plants at Pangabri Field, RAU, Pusa, while sugar was obtained from the local Pusa market. Leaves ranging in length from 300 to 500 mm were chosen and washed under running water to remove adhering materials before being wiped with muslin cloth. After washing, filleting is performed

[1] ICAR-Central Institute of Post-harvest Engineering and Technology, Ludhiana, India
[2] Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, India
[3] ICAR- Central Institute of Agricultural Engineering, Bhopal, India
*Corresponding Author E-mail: shaghaf.kaukab@gmail.com

with a stainless steel cutter to remove spikes along the margin and outer epidermal layer, as well as yellow exudates (laxative), to obtain parenchymatous tissue known as gel fillet (Fig. 1). The gel fillets were cut in to 40 mm diameter disc (approx. 10 mm thick) with the help of circular shaped cutter box. Few discs were kept in hot air oven for determining initial moisture content of the samples.

Fig. 1: Filleting of Aloe-vera leaves

Osmotic pre-treatment

Sucrose concentration of 30°, 40° and 50° Brix prepared with distilled water, were used for osmotic dehydration. Concentrations were checked by HRN-18 hand refractometer. The Aloe-vera discs of 20 g weight were immersed in the 250 ml glass beaker placed in hot water bath to reach desired temperature (30, 40 and 50°C) shown in Fig. 2. Osmotic dehydration was performed for 4 hours at constant syrup to product ratio (SPR) of 5:1. Every hour, one beaker was taken out of the water bath, the Aloe-vera discs were immediately rinsed with water and placed on absorbing paper to remove any surface moisture and their weight was recorded. All the experimental measurements were replicated 3 times. After osmotic treatment the samples were dipped in water at ambient temperature (30°C) or washed under water so as to remove the osmotic agents from the surface. They were then blotted on the absorbent paper to remove excess water.

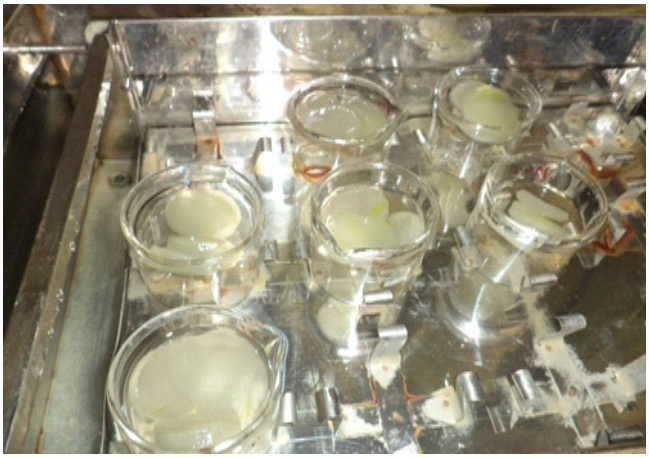


Fig. 2: Osmotic pretreatment

Determination of moisture loss and solute gain

The moisture content of fresh Aloe-vera discs was determined using AOAC method no. 934.06 (AOAC, 1990). The samples (20 g) were dried in the hot air oven at 102±2 °C for 24 hours. The dried weight (W_d) of the discs were measured and moisture content was calculated using formula:

$$MC\ (\%\ w.b.) = \frac{W_m}{W_m + W_d} \times 100 \quad (1)$$

Weight of moisture evaporation in interval of drying can be calculated as:

$$W_m = W_i - W_\theta \quad (2)$$

After osmotic treatment percent moisture loss was determined using formula:

$$ML\ (\%) = \frac{W_i X_i - W_\theta X_\theta}{W_i} \times 100 \quad (3)$$

And solute gain was determined by the formula:

$$SG\ (\%) = \frac{W_\theta(1-X_\theta) - W_i(1-X_i)}{W_i} \times 100 \quad (4)$$

Where, MC (% w.b.) = moisture content; ML (%) = percent moisture loss; SG (%) = percent solute gain; Wm = weight of moisture, g; Wd = dry weight of Aloe-vera discs, g; Wi = Initial weight of Aloe-vera discs, g; Wθ = Weight of Aloe-vera discs after time θ h, g; Xi = Initial moisture content; and Xθ = Moisture content after time θ h.

Hot air drying

The osmotically pre-treated Aloe-vera samples were further dried in a hot air dryer at PFE lab, CAE, Pusa. Known amount 108.52 g, 124.95 g and 215.86 g of osmotically pre-treated and raw Aloe-vera discs were kept in petridish and placed in the dryer for drying. Three replications of each sample were prepared. The samples were dried at 60 OC to maintain its quality characteristics. The drying was carried out to reduce moisture content of the sample to that level which was safe for its storage and stability.

Water activity

The water activity of dehydrated and dried samples was determined by using water activity meter available in the department of Processing and Food Engineering (PFE) lab. First, the sample was kept in the specimen port so as to cover full volume of port. The reading was then noted. It gives the direct reading of water activity of the sample.

Rehydration of dried Aloe-vera discs

The rehydration quality of dehydrated samples was determined by rehydration test (Ranganna, 1986). The samples of dehydrated control and osmosed samples were taken in individual beakers. 120 ml water was poured into each beaker, covered with a watch glass and placed on an electric heater for 5 min. Then sample was put into a Buchner funnel covered with a coarsely porous (Watchman no.4) filter paper. Gentle stroke was applied for 30 to 60 s to drain the excess water. The drained sample was weighed again and rehydration ratio was determined using formula:

$$R_r = \frac{W_r}{W_d} \quad (5)$$

Where,

R_r = rehydration ratio; W_r = weight of rehydrated sample after draining; W_d = Dry weight of dehydrated sample.

Colour

The Colour of dehydrated Aloe-vera disc was measured with the help of Hunter Colour Lab Meter available in the department of PFE. First, the instrument was calibrated using standard white and black tiles as per the standard procedure. Then samples were kept on the specimen port (dia. 95 mm) so as to cover the full exposed area of port emitting light and Hunter L, a, b values were noted. Hunter L_{Val} (which denotes the degree of whiteness) was chooses to represent the colour value of samples. In addition to Hunter L-value, a new parameter called Total Colour Index (E) was developed to represent the total colour of final dehydrated samples. The total colour index was calculated by formula.

$$E = \sqrt{L^2 + a^2 + b^2} \quad (6)$$

Where,

E = total colour index; L = Hunter L- value (100 is lightness, 0 is darkness); b = Hunter b - value (+ yellowness, - blueness); a = Hunter a - value (+ redness, -greenness)

Organoleptic evaluation

A Proforma consisting of basic organoleptic characteristic was prepared and evaluated on a 9 point hedonic scale as per method discussed by Ranganna (1986). A total of 15 people were asked to judge the product on the basis of their organoleptic properties for product acceptability.

Statistical analysis

All the treatments were replicated three times. Factorial CRD design was used for analysis of osmotic pre-treatment with three levels of concentrations, three levels of temperature and 4 levels of time. Tukey test was used as post hoc test. All analysis was conducted with SAS software version 9.3 and Microsoft excel 2010.

RESULTS AND DISCUSSION

Effect of temperature and concentration on moisture loss

Aloe-vera gel discs were subjected to osmotic dehydration at three different temperatures namely 30°, 40° & 50° C for different concentrations (30°, 40° & 50° Brix) of sugar solution. At any syrup concentration the moisture loss increases with increasing temperature while increasing concentration also increases moisture loss when temperature kept constant. This may be due to change in semi-permeability of cell membrane of the gel allowing more water to diffuse out in a shorter period. These findings were in confirmation with the result of Garcia-Segovia *et al.* (2010). However, higher temperature promoted faster water loss through swelling and plasticizing of cell membrane and better water transfer characteristics on the product surface due to lower viscosity of osmotic medium. Similar results were reported for osmotic dehydration of other commodities (Alam and Islam, 2013; Jain *et al.*, 2011).

The curve of best fit line between moisture loss & immersion time at different temperature and syrup concentration were obtained and plotted in fig. 3, 4 and 5, for Aloe-vera samples. It is very much clear from the graph that moisture loss increases with immersion time. Rate of water loss was rapid initially and rate decreased gradually with increase in immersion time. This could be due to reducing concentration gradient of moisture between product and solution with time. The statistical analysis of data gave a linear relationship between moisture loss (ML) and immersion time (t) with good coefficient of determination (R^2).

The mass transfer Model of aloe vera disc at 30°C for different sugar concentration:

At 30°B, $ML = 5.341\,t + 29.42$ ($R^2 = 0.92$) (7)

At 40°B, $ML = 6.261\,t + 29.225$ ($R^2 = 0.99$) (8)

At 50°B, $ML = 6.4265\,t + 31.867$ ($R^2 = 0.92$) (9)

Similarly, at 40°C:

At 30°B, $ML = 4.8755\,t + 32.01$ ($R^2 = 0.97$) (10)

At 40°B, $ML = 5.841\,t + 32.29$ ($R^2 = 0.96$) (11)

At 50°B, $ML = 5.499\,t + 36.73$ ($R^2 = 0.89$) (12)

Similarly, at 50°C:

At 30°B, $ML = 4.848\,t + 35.195$ ($R^2 = 0.89$) (13)

At 40°B, $ML = 6.083\,t + 35.26$ ($R^2 = 0.98$) (14)

At 50°B, $ML = 7.31\,t + 34.79$ ($R^2 = 0.96$) (15)

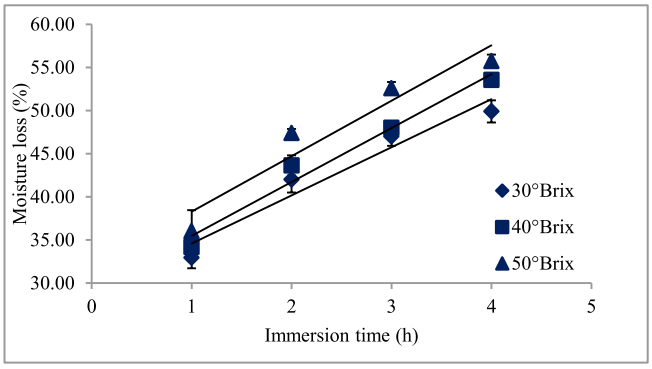


Fig. 3: Moisture loss at 30°C for different concentrations

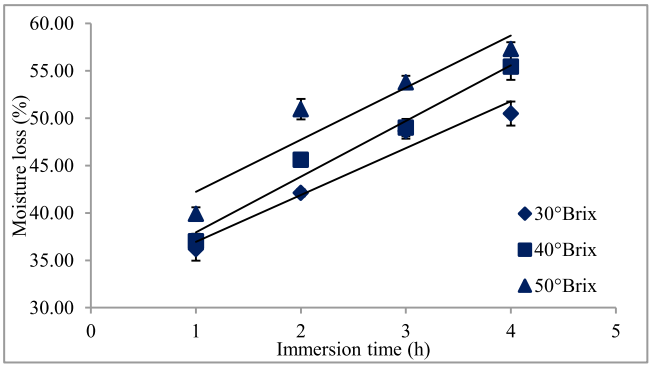


Fig. 4: Moisture loss at 40°C for different concentrations

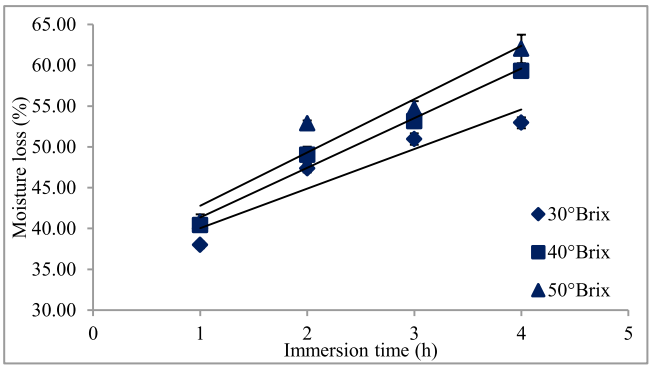


Fig. 5: Moisture loss at 50°C for different concentrations

Effect of temperature and concentration on solute gain

For constant temperature sugar gain increases with increase in sugar concentration of the solution from 30°B to 50°B. For example at 50°C the solute gain was 6.03%, 7.01% and 7.70% at 30°B, 40°B and 50°B respectively for 4 hr immersion time. But for constant sugar concentration the solute gain increases with increase in temperature from 30°C to 40°C. Maximum solid gain was observed in the sample at 40°C for all three osmotic concentrations. The slight decrease in solute gain on further increase solution temperature to 50°C, for e.g. at 30°B concentration the sugar gain was 4.843%, 7.43% and 6.03% at 30°C, 40°C and 50°C respectively for 4 hr immersion time. This could be attributed to increase in solubility of solute in the solution and also due to excess dilution of solution at 50°C decreases osmotic gradient due to excess loss of water from the sample, which retarded the solute uptake by the sample. This is in confirmation with Garcia-Segovia et al. (2010) where they confirmed that mass diffusion was highest at temperature 40°C for peeled Aloe-vera samples.

The curves between sugar gain and immersion time at different temperature and concentrations were obtained and presented in fig. 6, 7 and 8. The above findings can be clear from the graph which shows that sugar gain increases with immersion time. The same trend is followed for each temperature and concentration combinations. The statistical analysis establishes following linear relationship between sugar gain (SG) and immersion time (t):

The mass transfer model of aloe vera at 30°C for different sugar concentration:

At 30°B,	ML = 5.341 t + 29.42	(R^2 = 0.92)	(7)
At 30°B,	SG = 0.513 t + 2.805	(R^2 = 0.99)	(16)
At 40°B,	SG = 1.089 t + 2.525	(R^2 = 0.97)	(17)
At 50°B,	SG = 0.786 t + 3.905	(R^2 = 0.95)	(18)

Similarly, at 40°C:

At 30°B,	SG = 1.101 t + 2.955	(R^2 = 0.98)	(19)
At 40°B,	SG = 0.884 t + 4.395	(R^2 = 0.97)	(20)
At 50°B,	SG = 0.779 t + 4.975	(R^2 = 0.98)	(21)

Similarly, at 50°C:

At 30°B,	SG = 0.738 t + 3.41	(R^2 = 0.86)	(22)
At 40°B,	SG = 0.986 t + 3.185	(R^2 = 0.98)	(23)
At 50°B,	SG = 0.908 t + 3.815	(R^2 = 0.95	(24)

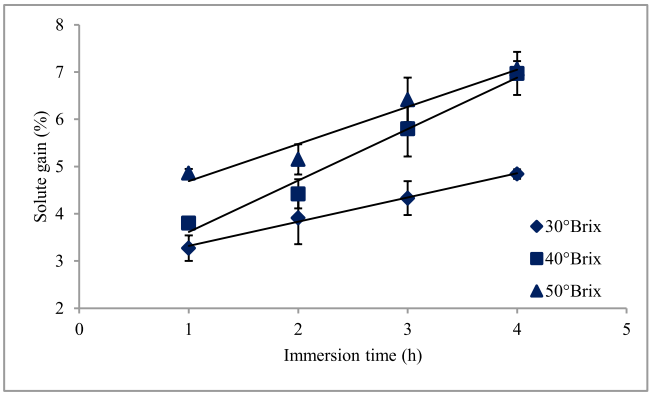


Fig. 6: Solute gain for different concentrations at 30°C

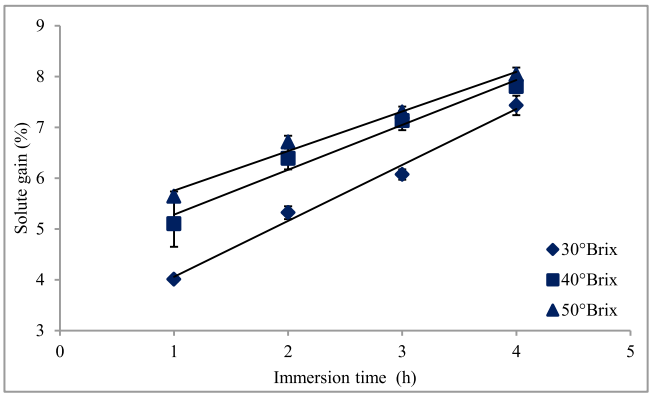


Fig. 7: Solute gain for different concentrations at 40°C

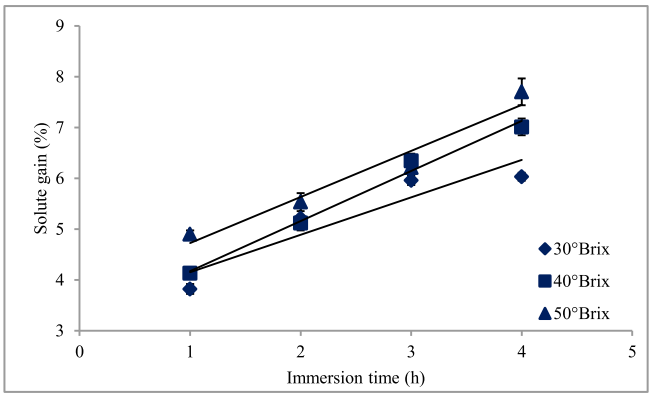


Fig. 8: Solute gain for different concentrations at 50°C

Selection of most suitable temperature and respective solute concentrations

The most suitable temperature and solute concentration for sugar solution was 50°C and 40°B for 4 h immersion time. This optimization was based on the maximum water loss, minimum solute gain as well as sensory evaluation of different quality parameters like colour, texture, taste appearance and overall acceptability using 9 point hedonic scale. The judges were asked to evaluate and assign marks to various osmotically treated Aloe-vera discs. Average score for the best treatment combination was 8.5, 8.01, 7.9, 8.0 and 8.5 for taste, colour, texture, appearance and overall acceptability for sugar solution. Based on the average score obtained the best treatment combination was selected for further drying to remove moisture up to safe storage of Aloe-vera discs.

Hot air drying of Aloe-vera gel discs

Untreated raw and osmotically treated samples with sugar solution were dried in the dryer at 70°C, because polysaccharides of Aloe-vera has been known to show maximal stability at 70°C, decreasing at higher and lower temperature (Scala *et al.*, 2013) and also best quality gel is produced at 60-70°C with minor effect on physiochemical, nutritional and antioxidant capacity of Aloe-vera (Miranda *et al.*, 2009). The moisture content of fresh raw and osmosed sample were 98.7 and 82.68 % (w.b.), respectively. The final moisture content of osmotically dehydrated dried and raw sample was found out to be 2.09 and 3.91 % (w.b.). The osmosed sample took 5 h 30 minute drying time to reduce to

moisture content to 2.09 % (w.b.) whereas raw sample took 7.30 h of drying time to reach to the moisture content of 3.91 % (w.b.). The difference in drying time of osmosed sample and raw sample was due to the presence of high initial moisture content in raw sample.

Water activity of Aloe-vera gel discs

The water activity of fresh Aloe-vera disc was 0.972, which signifies that Aloe-vera is highly unstable and prone to various deteriorative changes like enzymatic and oxidative changes etc. Whereas a_w of raw and osmotically dried samples were reduced to 0.592 and 0.716, respectively, signifying the stability of the processed product and the dried samples were safe from the action of many microorganisms even most mold and halophilic bacteria. Reduction in water activity is attributed to increase in solid content and reduction in available moisture from the aloe vera discs. This shows that drying and dehydration has significantly increased the shelf life of the Aloe-vera discs.

Rehydration characteristic of final product

Rehydration characteristic like rehydration ratio (RR) of osmosed sample and raw dried samples of Aloe-vera was determined (Table 1). Rehydration ratio was obtained in osmosed sugar sample which was 3.24 where as that of raw sample was 1.62. The highest value for moisture in rehydrated samples (% w.b) was found as 69.2% for the osmosed sample and that of raw sample was 38.5%. This depicted that the osmotically treated samples has the highest rehydration capacity than the raw and the rehydrated product could be very well utilized for other purposes.

Table 1: Rehydration characteristic of dried Aloe-vera gel discs

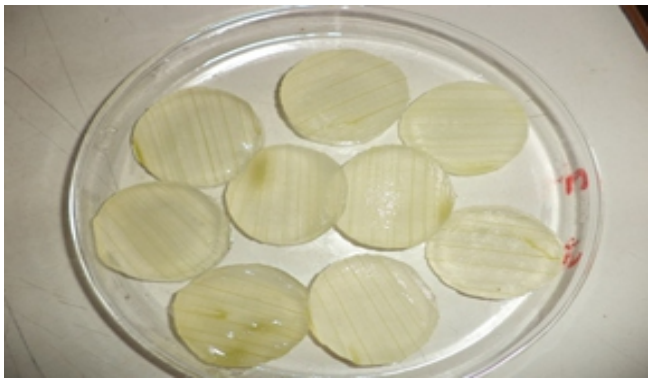
Sl. No.	Quality attributes	Osmosed sugar sample (Sg)	Raw
1	Moisture content (% w.b) of dried syrup	2.89	3.61
2	Moisture content (% w.b) of rehydrated sample	69.2	38.5
3	Rehydration Ratio	3.24	1.62

Colour of Aloe-vera discs

Colour of different Aloe-vera samples were determined with Hunter colour Lab and expressed in terms of two colour parameters viz. colour value (L, a, b) and total colour Index (E). The pictures of untreated and treated Aloe-vera samples were presented in fig. 9. These values were presented in the table 2 below.

Table 2: Colour paramrters of Aloe-vera discs

Type of sample	Hunter colour values			Total colour index (E)
	L	a	b	
Fresh raw sample	81.45	- 0.96	1.29	81.465
Dried raw sample	42.18	2.14	15.12	44.859
Osmosed sample	70.27	- 0.11	4.48	70.41



Fresh raw sample

Dried raw sample

Fresh osmosed sample

Dried osmosed sample

Fig. 9: Samples of Aloe-vera gel discs

The table 2 revealed that osmotically treated sample has the highest L value i.e. 70.27 while raw dried sample was the lowest in L value i.e. 42.18. This showed that the more deterioration of colour had occurred in raw sample. Similarly the total colour index (E) for the osmosed sample was higher than the raw dried sample. Hence it was found that osmotic dehydration played key role in development of best colour (highest E as 70.410), which was close to the fresh raw sample having total colour index as 81.46.

Organoleptic evaluation of the Aloe-vera discs.

The organoleptic evaluation of the osmotically dried sample and raw dried sample as well as rehydrated samples was done by a panel of 15 judges based on 9-point hedonic scale for different quality attributes of the sample presented in the and fig. 10 below.

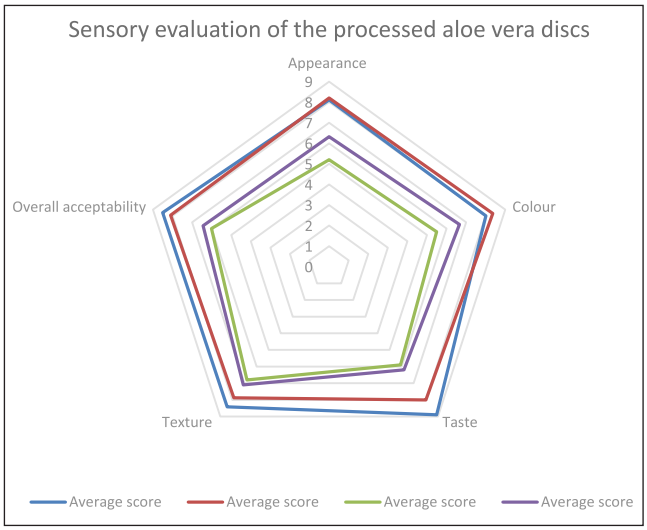


Fig. 10: Values are average of 15 replications

From the fig. 10 it is very much clear that the average score given by the panelist for different quality attributes like colour, texture, taste, appearance and overall acceptability for osmosed samples were higher than the untreated raw samples. Among all the samples osmotically dried sample with sugar has got the highest score for overall acceptability as 8.51 followed by rehydrated samples of osmosed Aloe-vera disc which was 8.1. This again clearly showed that osmotically dehydrated as well as its rehydrated samples were better than raw samples in overall acceptability.

CONCLUSION

Osmotic dehydration used as processing technique for Aloe-vera gel discs. Water loss (%) increased with increase in osmotic solution temperature, solution concentration and immersion time. The water loss from and solute gain was very rapid during initial period, it increased with duration of osmosis at all concentrations. The optimized parameter for osmotic treatment of Aloe-vera gel discs was found to be 40°Brix and 50°C. Drying results in final reduction of moisture content to obtain stable best quality product at 70°C. Final moisture content after drying was 2.09% and 3.91% (w.b) for osmosed sample and raw sample. Osmotic treatment also helped in better retention of colour of the final dried product. The osmotically treated Aloe-vera discs were found best in colour, appearance, taste, texture and overall acceptability. From this study, it can be concluded that osmotic dehydration is an effective processing technique for obtaining best quality Aloe-vera product.

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