



P-ISSN: 2349-8528

E-ISSN: 2321-4902

www.chemijournal.com

IJCS 2020; 8(2): 2501-2509

© 2020 IJCS

Received: 20-01-2020

Accepted: 22-02-2020

**SP Cholera**

PhD (Agril. Engg.), Assistant Professor, Deptt. of Processing & Food Engg., CAET, JAU, Junagadh, (Gujarat), India

**MB Kapopara**

MSc (Home Science) in Food & Nutrition, Asst. Ext. Edu., Bakery School, JAU, Junagadh, (Gujarat), India

**PJ Rathod**

Assistant Professor, Deptt. of Biochemistry, College of Agriculture, JAU, Junagadh, (Gujarat), India

**SD Jadav**

B.Tech. (Agril. Engg.), CAET, JAU, Junagadh, (Gujarat), India

**DL Pranami**

B.Tech. (Agril. Engg.), CAET, JAU, Junagadh, (Gujarat), India

**Corresponding Author:****SP Cholera**

PhD (Agril. Engg.), Assistant Professor, Deptt. of Processing & Food Engg., CAET, JAU, Junagadh, (Gujarat), India

## Physico-Chemical analysis of honey based herbal gooseberry candies

SP Cholera, MB Kapopara, PJ Rathod, SD Jadav and DL Pranami

DOI: <https://doi.org/10.22271/chemi.2020.v8.i2a1.9126>

**Abstract**

The Indian gooseberry (*Emblica officinalis* L.) is one of the cheapest medicinal fruits due its highest ascorbic acid content 160 times than that of apple. A novel concept of osmotic dehydration by preparing osmotic solution (i.e., 60 °β and 70 °β) using 1:5 (w/w) sucrose-honey combination incorporated with natural herb powders, viz., cardamom, ginger, basil and salt as a preservative. The osmotic dehydration (OD) of gooseberry segments (10 mm thick) were carried out at different process temperatures (i.e., 30°C, 40°C and 50 °C) at an immersion time of 10 h followed by hot air drying (60°C and 2.50 m/s) and sun drying (control). The quality evaluation of gooseberry candies was carried out on the basis of physical parameters (i.e., rehydration ratio, and biochemical parameters (i.e., moisture content (%wb)), non-enzymatic browning (OD), total sugar (%), ascorbic acid (mg/100 g) and reducing sugar (%)), microbial as well as sensory analysis. It can be concluded that honey based herbal gooseberry candies prepared by the sun drying method was found to be the best on the basis of higher rehydration ratio (2.89), NEB (0.05 OD), ascorbic acid (138.78 mg/100 g), total sugar (61.92 %), reducing sugar (35.14 %) and highest sensory score (7.83) as compared to hot air drying.

**Keywords:** osmotic dehydration, gooseberry candy, osmo-air drying

**Introduction**

India is the world's third largest gooseberry producer with the annual production of gooseberry of 1075000 tons under an area of 93000 hectares with an average productivity of 11.55 tons/ha. Uttar Pradesh ranks first in the production of gooseberry, followed by Madhya Pradesh, Tamil Nadu, Gujarat and Chhattisgarh are top five states producing bumper gooseberry production in India. Gujarat ranks fourth in gooseberry production in India with the annual production 81900 tons under an area of 8150 hectares with an average productivity of 10.05 tons/ha during the year 2017-18 (Anonymous, 2018) [1].

Aonla or Indian gooseberry (*Emblica officinalis* Gaertn.) is one of the most important traditional and underutilized fruits of Indian origin, having immense potential for cultivation on marginal or waste lands. It belongs to the family Euphorbiaceae and sub-family Phyllanthoidae. The fruit is highly nutritive and richest source of vitamin C among fruits after Barbados cherry. The edible fruit tissues of aonla contain about 3 times more protein and 160 times more vitamin C as compared to apple Barthakur and Arnold (1991) [2].

It contains several chemical constituents like tannins, alkaloids and phenols. 4 among all hydrolysable tannins, Emblicanin A and B; gallic acid, ellagic acid are reported to possess biological activity. Almost all parts possess medicinal properties, particularly fruit, which has been used in Ayurveda as a powerful rasayana and in customary medicine in the treatment of diarrhoea, jaundice, inflammation and several other ailments Udupa (1985) [26]

The fruit, due to its sour and astringent taste, has very limited table value. The fresh fruits are generally not consumed due to their high astringency but it has got great potential in processed forms. Aonla fruits are highly perishable in nature and hence its storage in atmospheric conditions after harvesting is very limited (Kumar and Nath (1993)) [14]. Due to its perishable nature, it is difficult to store or transport gooseberry fruits over long distances. In order to have good income from gooseberry, it must be sold immediately after harvesting in the market. But, the problem arises when there is glut in the market. To get profit during that period, proper storage facilities should be available to help the farmers get maximum profit (Goyal *et al.* (2008) [7].

Honey is naturally occurring syrup, which contains glucose, fructose, vitamins and minerals. Honey is famous for ideal remedies for stomachaches, dehydration, damage in intercellular structure, allergies, skin and hair problems, improves eye sight, astringent, cosmetics, and act as antiseptic, antibacterial and preservative effects on human and foods. Kamboj *et al.* (2017) [10] optimized different parameters for osmotic dehydration of apples, i.e., concentration of sucrose in honey, temperature, time and solution to fruit ratio were 100:13, 60 °C, 420 minutes and 2:1, respectively. Several researchers have found better results by using sucrose and honey mixture as an osmotic solution. Bawa and Gujral (2000) [3] evaluated the effect of sucrose and honey solution on water loss and solid gain. They observed that the rate of moisture loss in the fruit varies with both the agents as well as their concentrations in the soak solutions at ambient temperature. The sensory scores indicated that the honey treated samples have better flavor while sugar treated ones better color and overall acceptability.

Sethi and Kaur (2019) [19] showed that the pineapple sample cubes treated with honey sucrose solution (1:1) at 50 °C temperature were found to have better rehydration characteristics and lowest moisture content value as compared to the other samples treated with honey and sucrose separately. Sensory evaluation of all the samples revealed that highest scores were obtained by the sample containing both sucrose and honey (50 °C). Highest ascorbic acid content after the osmotic dehydration was found in sample with sucrose and honey. Hence, sample treated with combination of sucrose and honey solution at 50 °C proved to be the best in terms of nutritional quality, shelf stability and all other tested parameters.

Cardamom is one of the world's oldest spices, traditionally used as a flavoring and natural food preservative. The oleoresin from cardamom was recently tested as a natural food preservative by a research group at Gorakhpur University in India in a classic storage study; to maintain quality of a sweet orange (*Citrus sinensis*) juice (Kapoor *et al.*, 2011) [11]. Recent research shows a methanolic extract of large Cardamom is effective against various enteropathogenic and food spoilage bacteria (Garg *et al.*, 2016) [6]. It was also reported that ginger has a moderately good antimicrobial activity. Shelf-life of unripe cheese was extended by 15 days by treatment with ginger extract (Belew *et al.* 2005) [4].

Tulsi also known as holy basil belongs to the family Lamiaceae. The leaves are a good tonic for nervous system and also improve memory power. The fresh leaves have more leaves antibacterial properties and the dried leaves powder have more antifungal properties. Due its antibacterial properties, Basil leaves were incorporated in Portugal "Serra da Estrela" cheese to test their functional and preservative properties (Carocho *et al.*, 2016) [5].

Typical spices high in antioxidants (confirmed *in vitro*) are turmeric, basil, ginger, pepper, chili powder, paprika, garlic, coriander, onion and cardamom (Tyler (1994) [25]. Herbs and spices containing essential oils in the range of 0.05–0.1% have demonstrated activity against pathogens (Tajkarim *et al.*, 2010) [21]. These spices are well tolerated by most people and generally recognized as safe (Supreetha *et al.*, 2011) [20].

The post-harvest losses in gooseberry vary from 30 to 40 % due to its perishable nature, which reduces the market value. Appropriate storage and processing methods can curtail the post-harvest losses to 30% (Goyal *et al.*, 2008) [7] and make the fruit available for longer period (Singh *et al.*, 2009). Value addition through processing would be the only effective tool

for economic utilization of increased production of gooseberry in the future. Processing of gooseberry not only reduces the post-harvest losses but also provides higher returns to the growers and processors. A number of value-added products such as murabba, pickle, candy, juice, squash, jam, jelly, powder, etc., are prepared from gooseberry. [Kalra C. L. (1988) [9]; Tandon *et al.* 2003 [22]; Tripathi *et al.*, 1988 [23])

Presently, osmotic drying prior to hot air drying gives better qualities of final products on basis of color, flavor, texture, aroma, taste as well as better retention of vitamins, minerals, volatile compounds, polyphenols which permits longer shelf life of the final product. The addition of herbs like cardamom, ginger, Tulsi and honey in osmotic solution will supplement all the nutritional and medicinal qualities of these herbs in the final osmotically dehydrated product (gooseberry candy).

Therefore, present investigation was undertaken with a novel concept of incorporating natural herbs in osmotic dehydration of gooseberry segments prior to hot air drying was introduced for better and consistent final dried product having higher nutritional as well as medicinal values. Finally, different quality parameters of honey based herbal gooseberry candies prepared by different treatment combinations were analyzed on the basis physical, biochemical, sensory and microbial analysis.

## Methods and Materials

All the experiments for preparation of honey based herbal candies from gooseberry (Cv. *Gujarat-1*) were carried out at the Department of Processing and Food Engineering, College of Agricultural Engineering & Technology, Junagadh Agricultural University, Junagadh. Freshly harvested gooseberry fruits were procured from local wholesaler market of Junagadh.

## Physical and biochemical parameters of fresh gooseberry fruits

The physical parameters, viz., fruit weight, maximum and minimum diameter, pulp to stone ratio, firmness and cutting force of fresh gooseberry fruits were measured. Firmness and cutting force were measured using texture analyzer (Stable Micro Systems – UK, Model: TA-XT2i) using 50 kg load cell. The biochemical parameters viz., total sugar, ascorbic acid reducing sugar, as well as moisture content of fresh gooseberry fruits were also measured as per standard methods.

## Osmotic dehydration of gooseberry

Osmotic dehydration of 10 mm gooseberry segments was carried out (Plate 1) at different osmotic variables, viz., osmotic solution concentration (60<sup>0</sup> and 70<sup>0</sup>β), process temperature (30<sup>0</sup>, 40<sup>0</sup> and 50<sup>0</sup>C) and sample to solution ratio (1:4 and 1:5) at a constant immersion time (10 h). Osmotic solution was prepared using sucrose and honey as an osmotic agent in 1:5 (w/w) proportions. Addition of natural herbs, viz., cardamom powder @ 0.5% (w/w), ginger powder @ 1% (w/w) + tulsi powder @ 1% (w/w) as well as salt @ 0.5% (w/w) in osmotic solution to get nutritional, medicinal and anti microbial benefits. Salt was added to accumulate the osmotic dehydration process.

Osmotic solution of 60<sup>0</sup>β concentration required 900 g of sugar and 180 g of honey in distilled water. Concentration of osmotic solution was measured with the help of hand refractometer (Erma-Tokyo: 58-92<sup>0</sup>β). Herbal powders, viz., ginger powder (10.8 g), tulsi powder (10.8 g), elaichi powder

(5.4 g) as well as iodized salt (5.4 g) were added and stirred till dissolved in the solution. Similarly, 70° osmotic solution required 1020 g of sugar and 204 g of honey supplemented with ginger powder (12.24 g), Tulsi powder (12.24 g), elaichi powder (6.12 g) as well as iodized salt (6.12 g). Addition of 200 g and 250 g of gooseberry segments (10 mm thick) in 1 kg of osmotic solution in glass jars for maintain sample to solution ratio 1:4 and 1:5, respectively. Then lidded glass jars

were kept at 30°, 40° and 50°C process temperature for 10 h immersion time in BOD incubator as per their treatment combinations. Total 12 numbers of osmotically dehydrated gooseberry samples were obtained from respective 12 glass jars of different treatment combinations in one experiment. Osmotic dehydration of fresh gooseberry segments was carried out considering three factors Completely Randomized Design with three replications.



Plate 1: Osmotic dehydration of gooseberry segments

The solid gain (SG), water loss (WL), water loss to solid gain ratio (WL/SG) and weight loss were measured as per the method reported by Islam and Flink (1982) [8]. Moisture content measured as per Rangana (2010) [15] method, whereas total sugar, ascorbic acid and reducing sugar were measured per method suggested by Sadasivam and Manickam (1996)

[16]. Best treatment among all the 12 treatments on the efficiency of osmotic dehydration was determined and hence, osmotically dehydrated gooseberry segments obtained by best treatment were selected for further hot air and solar drying. The complete details of various processing operations are mentioned in process flow chart (Fig. 1).

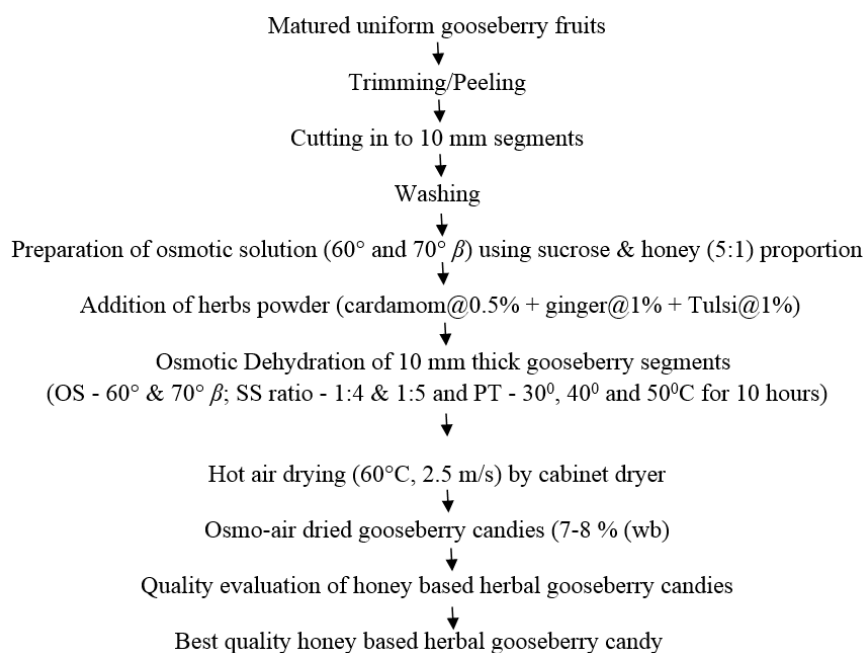


Fig 1: Process flow chart of honey based herbal gooseberry candy

#### Hot air drying of osmotically dehydrated gooseberry

Hot air drying of gooseberry segments was carried out at 60° C drying air temperature and 2.5 m/s air velocity at 10 mm bed thickness i.e., single layer, using laboratory level tray dryer. The observations of weight loss at the interval of 1 h were recorded. The drying of osmosed segments was continued till the desired moisture content (i.e., 7 to 8 % (wb)) was obtained.

#### Sun drying of osmosed gooseberry segments

The sun drying of gooseberry segments was carried out during 8.00 AM to 6.00 PM (i.e., 10 h). Osmotically

dehydrated segments were spread in a uniform layer of 10 mm bed thickness on a 100 μ paper sheet. After 18.00 hours, the sun-dried segments were taken out and covered in high density polythene bag. This air tight bag was kept laboratory during overnight period. The same process was repeated for the next day till the desired moisture contents (7 to 8 % (wb)) of the segments was obtained.

Drying parameters, viz., moisture content, drying rate and moisture ratio (MR) at different drying time during hot air drying as well as sun drying were determined. The values of drying constant (k) were also determined for hot air drying and sun drying method.



**Plate 2:** Osmo-air dried honey based herbal gooseberry candies

### Quality analysis of honey based herbal gooseberry candies

The quality analysis of hot air dried and sun-dried gooseberry candies was carried out on the basis of physical parameter, i.e., rehydration ratio (RR) and biochemical parameters, viz., total sugar, ascorbic acid, reducing sugar as per standard methods. The non-enzymatic browning of the gooseberry candies were determined by the method suggested by Ranganna (2010) [15]. However, sensory analysis on the basis of different sensory attributes, viz., color, texture, taste, appearance and overall acceptability was carried out by 10-point hedonic test as suggested by Ranganna (2010) [15].

Finally, 100 g honey based herbal gooseberry candies samples were packed and sealed in 50  $\mu$  low density polyethylene (LDPE), 50  $\mu$  high density polyethylene (HDPE), 50  $\mu$  polypropylene (PP) and 50  $\mu$  laminated aluminum foil pouches (LAFP) at 300 and 700 mm Hg vacuum pressure for further storage studies using vacuum packaging machine, "Powervac" single chamber trolley model.

### Results and Discussion

The physico-chemical parameters of uniform sized, well graded and matured fresh gooseberry fruits (cv. Gujarat 1) were determined and reported in Table 1.

**Table 1:** Physico-chemical parameters of fresh gooseberry fruits

Sam-ple No.	Moisture content		Fruit weight (g)	Diameter (mm)		Pulp to Stone Ratio	Firm-ness (kg)	Cutt- ing Force (kg)	AA (mg/100 g)	TS (%)	RS (%)
	% (wb)	% (db)		Max	Min						
S <sub>1</sub>	82.90	485.93	34.20	40.64	33.67	13.23	5.57	26.84	528.61	6.07	6.01
S <sub>2</sub>	82.30	482.41	32.15	39.17	33.64	12.54	7.03	28.19	557.89	6.11	5.38
S <sub>3</sub>	82.10	481.24	32.30	38.86	34.82	13.33	6.66	27.38	537.86	6.52	5.30
S <sub>4</sub>	83.10	487.10	34.18	39.91	35.26	12.43	6.75	30.9	557.91	7.01	5.43
S <sub>5</sub>	82.70	484.75	33.11	40.28	32.23	12.96	6.46	25.17	548.53	6.44	6.21
SD ( $\pm$ )	0.41	2.43	0.98	0.75	1.18	0.40	0.56	2.10	12.83	0.38	0.41
Mean	82.62	484.29	33.18	39.77	33.92	12.90	6.50	27.70	546.16	6.43	5.67

AA – Ascorbic acid ; TS – Total sugar ; RS – Reducing sugar

The mean values of fruit weight, maximum and minimum, pulp to stone ratio, firmness and cutting force of fresh gooseberry fruits with their standard deviations were found to be  $33.18 \pm 0.98$  g,  $39.77 \pm 0.75$  mm &  $33.92 \pm 1.18$  mm,  $12.90 \pm 0.40$ ,  $6.50 \pm 0.56$  kg and  $27.70 \pm 2.10$  kg, respectively (Table 1). Also, the mean values of ascorbic acid (AA), total sugar (TS) and reducing sugar (RS) of fresh gooseberry fruits with their standard deviations were found to be  $546.16 \pm 12.83$  mg/100 g,  $6.43 \pm 0.38$  % and  $5.67 \pm 0.41$  %, respectively (Table 1). The mean values of moisture content, ascorbic acid (AA), total sugar (TS) and reducing sugar (RS) were slightly lower as compared to mean values reported by

Tyagi and Dhawan (2017) [24] for proximate analysis of fresh gooseberry (aonla) fruits, these might be due difference in varieties of gooseberry fruits.

### Osmotic dehydration

The osmotic characteristics, i.e., water loss (WL), solid gain (SG), water loss (WL) to solid gain (WL/SG) ratio and weight loss were measured. The mean values of these osmotic characteristics for 12 treatment combinations are reported in Table 2, whereas statistically analyzed values are reported in Table 3.

**Table 2:** Effect of osmosis on different osmotic characteristics

Sr. No.	Treatments	Water loss, %	Solid gain, %	WL/SG	Weight loss, %	Moisture content (% (wb))
1	T <sub>1</sub> (C <sub>1</sub> S <sub>1</sub> P <sub>1</sub> )	40.76	7.65	5.33	33.11	63.00
2	T <sub>2</sub> (C <sub>1</sub> S <sub>1</sub> P <sub>2</sub> )	42.24	7.82	5.40	34.42	62.00
3	T <sub>3</sub> (C <sub>1</sub> S <sub>1</sub> P <sub>3</sub> )	46.50	8.19	5.68	38.31	59.00
4	T <sub>4</sub> (C <sub>1</sub> S <sub>2</sub> P <sub>1</sub> )	42.42	7.71	5.50	34.71	62.00
5	T <sub>5</sub> (C <sub>1</sub> S <sub>2</sub> P <sub>2</sub> )	43.90	7.84	5.60	36.06	61.00
6	T <sub>6</sub> (C <sub>1</sub> S <sub>2</sub> P <sub>3</sub> )	46.21	7.36	6.28	38.84	60.00
7	T <sub>7</sub> (C <sub>2</sub> S <sub>1</sub> P <sub>1</sub> )	42.38	8.81	4.81	33.57	61.00
8	T <sub>8</sub> (C <sub>2</sub> S <sub>1</sub> P <sub>2</sub> )	45.13	10.25	4.40	34.88	58.00
9	T <sub>9</sub> (C <sub>2</sub> S <sub>1</sub> P <sub>3</sub> )	49.22	10.45	4.71	38.77	55.00
10	T <sub>10</sub> (C <sub>2</sub> S <sub>2</sub> P <sub>1</sub> )	48.54	13.37	3.63	35.16	53.00
11	T <sub>11</sub> (C <sub>2</sub> S <sub>2</sub> P <sub>2</sub> )	49.89	13.37	3.73	36.51	52.00
12	T <sub>12</sub> (C <sub>2</sub> S <sub>2</sub> P <sub>3</sub> )	53.16	13.86	3.84	39.30	49.00

Osmotic Solution Concentration (C) :  $C_1 = 60^\circ\text{B}$ ;  $C_2 = 70^\circ\text{B}$   
 Sample to solution ration (S) :  $S_1 = 1:4$ ;  $S_2 = 1:5$   
 Process temperature (P) :  $P_1 = 30^\circ\text{C}$ ;  $P_2 = 40^\circ\text{C}$ ;  $P_3 = 50^\circ\text{C}$

### Effect of osmotic parameters

Table 2 revealed that water loss (WL), solid gain (SG), weight loss of gooseberry segments increased with increase in concentration of osmotic solution (60 and 70 °B), sample to solution ratio (1:4 to 1:5) and process temperature (30 °C to 50 °C). The lowest water loss of 40.76 % was obtained in treatment T<sub>1</sub>(60 °Brix osmotic solution+ 1:4 sample to solution ratio + 30 °C process temperature) and highest water loss of 53.16 % was obtained in treatment T<sub>12</sub> (70 °Brix osmotic solution + 1:5 sample to solution ratio + 50 °C process temperature). Whereas, lowest solid gain of 7.36 % was obtained in treatment T<sub>6</sub> (60 °Brix osmotic solution + 1:5 sample to solution ratio + 50 °C process temperature) and highest solid gain of 13.86 % was obtained in treatment T<sub>12</sub> (70 °Brix osmotic solution + 1:5 sample to solution ratio + 50 °C process temperature).

This might be attributed to complex phenomena of mass transport of osmotic solution during osmotic dehydration for treatment combination of treatment T<sub>6</sub> (60 °Brix osmotic solution + 1:5 sample to solution ratio + 50 °C process temperature) resulted in lower solid gain. Furthermore, increase concentration of osmotic solution will creates more osmotic pressure on gooseberry segments will resulted in to more water loss (WL) and solid gain (SG). In addition to this, increase in sample to solution ratio (1:4 to 1:5) allows decreases in quantity of gooseberry segments in the same volume of osmotic solution, thus, this will be resulted in more water loss (WL) and less solid gain (SG).

The results of similar pattern for different osmotic characteristics were reported by Kshirsagar (2006) [12] for sapota slices, Sagar and Kumar (2009) [17] for mango slices and Kumar and Devi (2011) [13] for pineapple slices.

Furthermore, raise in process temperature from 30 °C to 50 °C will accelerates the process of heat and mass transfer in presence of salt. This will be resulted in to more water loss (WL) of gooseberry segments as compared to solid gain (SG). It was also observed that, the moisture content of gooseberry segments decreased with increase in concentration of osmotic solution (60 and 70 °B), sample to solution ratio (1:4 to 1:5) and process temperature (30 °C to 50 °C). This is also in accordance to increase concentration, sample to solution ratio as well as process temperature will stimulate the osmotic dehydration process, thus, resulted in more release of water, i.e., less moisture contents of the final products.

Statistically anal zed data (Table 3) revealed that individual effect of osmotic solution concentration (S), sample to solution ratio (S) and process temperature (P) was found significant on water loss (WL), solid gain (SG), WL/SG, weight loss and moisture content of gooseberry segments during osmotic dehydration. Also, the effect of interaction (CxS) between osmotic solution concentration (C) and sample to solution ratio (S) was also found significant on water loss (WL), solid gain (SG), WL/SG, weight loss and moisture content of gooseberry segments.

Furthermore, the effect of interactions, i.e., CxP, SxP and CxSxP were found non-significant on water loss (WL), solid gain (SG), WL/SG, weight loss and moisture content of gooseberry segments during osmotic dehydration.

The value of ratio of water loss to solid gain (WL/SG) in osmotic dehydration is an indication of efficient process. The process of osmotic dehydration always aims to minimum

uptake of solid (sugar) with maximum release of water. So, high value of water loss to solid gain indicated that there was intensive water removal from the gooseberry segments accompanied with minimal solid gain. It was observed that (Fig. 2, 3 & 4) the highest value of water loss to solid gain ratio was 6.28 % obtained in treatment T<sub>6</sub> (C<sub>1</sub>S<sub>2</sub>T<sub>3</sub>), whereas lowest of 3.63 % in treatment O<sub>10</sub> (C<sub>2</sub>S<sub>2</sub>T<sub>1</sub>).

### Efficiency of Osmotic Dehydration Process

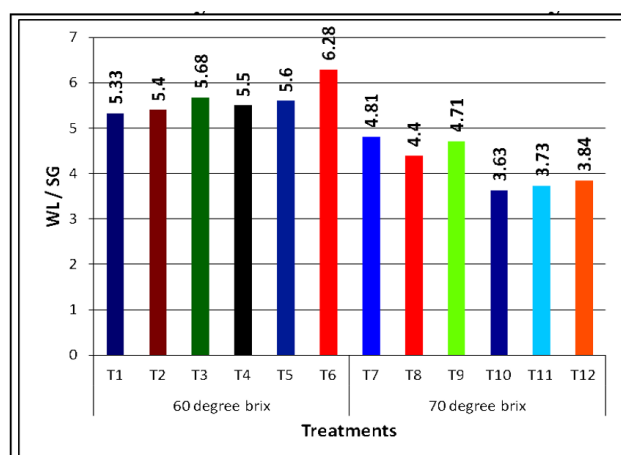


Fig 2: Effect of OS concentration on WL/SG

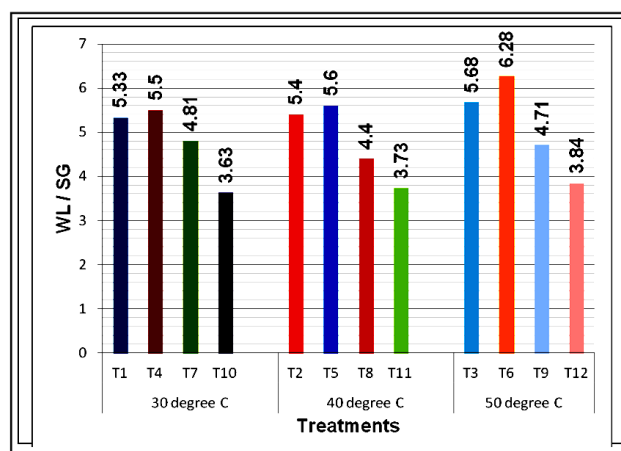


Fig 3: Effect of process temperature on WL/SG

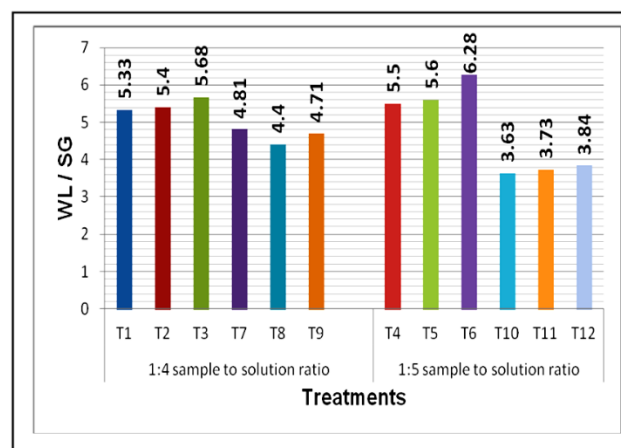


Fig 4: Effect of SS ratio on WL/SG

**Table 3:** Statistical analyzed values of water loss, solid gain, WL/SG, weight loss and moisture content during osmosis

Treatment	Water loss (%)	Solid gain (%)	WL/SG	Weight loss (%)	Moisture content (% (wb))
<b>Osmotic solution concentration (C)</b>					
C <sub>1</sub> (60° β)	43.67	7.76	5.63	35.91	61.17
C <sub>2</sub> (70° β)	48.05	11.69	4.19	36.37	54.67
S.Em.±	0.54	0.14	0.08	0.24	0.68
C.D. at 5 %	1.58	0.41	0.24	0.65	1.80
<b>Sample to solution ratio (S)</b>					
S <sub>1</sub> (1:4)	44.37	8.86	5.06	35.51	59.67
S <sub>2</sub> (1:5)	47.35	10.59	4.76	36.76	56.17
S.Em.±	0.54	0.14	0.08	0.26	0.66
C.D. at 5 %	1.58	0.41	0.24	0.75	2.00
<b>Process temperature (P)</b>					
P <sub>1</sub> (30° C)	43.53	9.39	4.82	34.14	59.75
P <sub>2</sub> (40° C)	45.29	9.82	4.78	35.47	58.25
P <sub>3</sub> (50° C)	48.77	9.97	5.13	38.81	55.75
S.Em.±	0.66	0.17	0.10	0.31	0.84
C.D. at 5 %	1.94	1.15	0.29	0.92	2.45
C.V. %	5.02	6.18	7.10	3.01	5.01
<b>CxS</b>					
S.Em.±	0.77	0.20	0.12	0.36	0.97
C.D. at 5 %	2.24	0.58	0.34	0.12	2.83
<b>CxT</b>					
S.Em.±	0.94	0.25	0.14	0.44	1.19
C.D. at 5 %	NS	NS	NS	NS	NS
<b>SxT</b>					
S.Em.±	0.94	0.25	0.14	0.44	1.19
C.D. at 5 %	NS	NS	NS	NS	NS
<b>CxSxT</b>					
S.Em.±	1.33	0.35	0.20	0.63	1.68
C.D. at 5 %	NS	NS	NS	NS	NS

The objective of this work was to study the osmotic dehydration as a pretreatment before hot air drying of gooseberry segments as a function of osmotic concentration, sample to solution ratio and process temperature in order to identify best process conditions for a high water loss at minimal solid uptakes (as an extensive sugar uptake is undesirable and the product can no longer be marketed as 'natural').

A novel concept of addition of honey with sucrose (1:5 proportion) in osmotic solution as an osmotic agent incorporated with ginger, cardamom and tulsi powder to enhance diffusion of these natural herbs in gooseberry segments during osmosis will increase nutritional and medicinal values of the final candied product as well as better retention of vitamins, minerals, anti-oxidants, phenolic compounds, etc., in further hot air drying and sun drying.

From the present study, it can be concluded that the treatment T<sub>6</sub> (i.e., 60 °Brix sucrose solution + 1:5 sample to solution ratio + 50 °C temperature) was found to be the best among all the treatments after considering water loss to solid gain ratio as a efficiency of process parameters for optimum condition of osmotic dehydration. Hence, osmotically dehydrated

gooseberry segments obtained by treatment T<sub>6</sub> was selected for further hot air drying and sun drying.

#### Hot air drying and sun drying

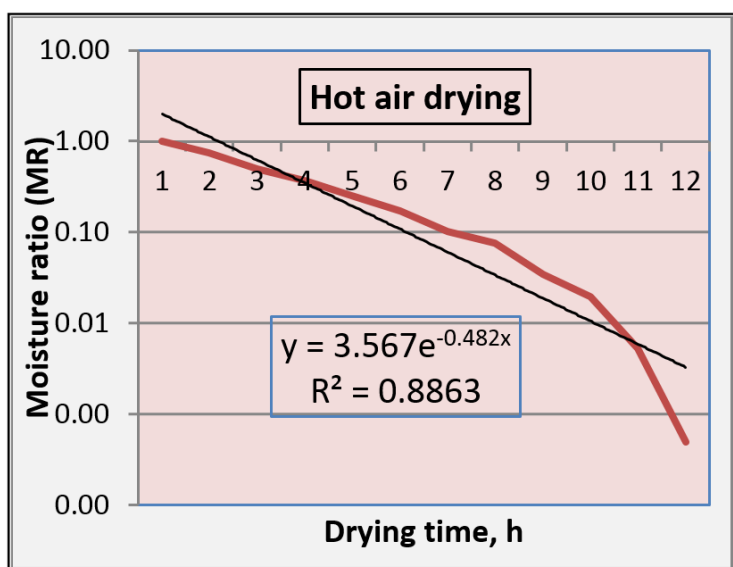
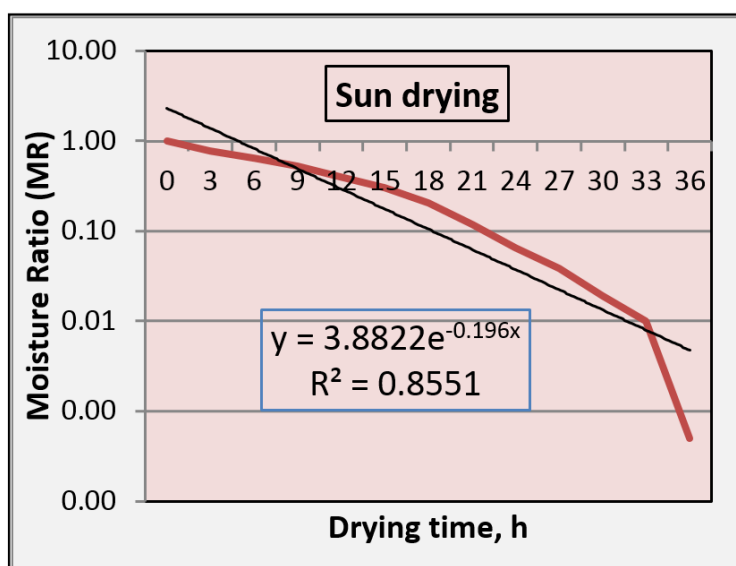
The hot air drying of osmotically dehydrated gooseberry segments obtained by different treatment T<sub>6</sub> was carried out at 60° C and 2.5 m/s air velocity at 10 mm bed thickness. The values of moisture content, drying rate and moisture ratio were recorded at an interval of 1 hour and 3 hours for hot air drying and sun drying, respectively and reported in Table 4.

Hot air drying took only 11 hours of drying time to reduce the moisture contents of osmosed gooseberry segments from 60.00 % (wb) to 7.87 % (wb), whereas sun drying required 36 hours (4 days) to reduce moisture content of gooseberry segments from 60.00 % (wb) to 7.40 % (wb). The final moisture content of honey based herbal gooseberry candy was considered as equilibrium moisture content (EMC) for calculation of drying efficiency in terms of drying constant. In accordance to this, higher value of drying constant (k) of 0.482 h<sup>-1</sup> was obtained in hot air drying as compared to that of 0.196 h<sup>-1</sup> in sun drying.

**Table 4:** Mean values of moisture content, drying rate and moisture ratio at different drying time for hot air drying and sun drying.

Sr. No.	Hot air drying using cabinet dryer					Sun drying				
	DT, h	MC, % (wb)	MC, % (db)	DR, % (wb)/h	MR	DT, h	MC, % (wb)	MC, % (db)	DR, % (wb)/h	MR
1	0	60.00	150.00		1.00	0	60	150.00		1.00
2	1	49.93	99.71	10.07	0.81	3	52.12	108.86	7.88	0.85
3	2	35.91	56.03	14.02	0.55	6	44.44	79.99	7.68	0.71
4	3	28.30	39.46	7.61	0.40	9	37.26	59.39	7.18	0.57
5	4	21.60	27.55	6.70	0.28	12	30.46	43.79	6.80	0.44
6	5	17.11	20.64	4.49	0.19	15	24.84	33.05	5.62	0.34
7	6	13.12	15.10	3.99	0.12	18	19.27	23.87	5.57	0.23
8	7	11.72	13.27	1.40	0.09	21	14.20	16.55	5.07	0.14
9	8	9.31	10.27	2.41	0.05	24	11.12	12.52	3.08	0.08
10	9	8.75	9.59	0.56	0.04	27	9.88	10.96	1.24	0.06
11	10	8.23	8.97	0.52	0.03	30	8.74	9.58	1.14	0.04
12	11	7.87	8.54	0.36	0.02	33	8.15	8.87	0.59	0.01
13	--	--	--	--	--	36	7.69	8.33	0.46	0.00

DT = Drying time MC =Moisture content DR = Drying rate MR = Moisture Ratio

**Fig 5:** Moisture Ratio vs. Drying Time for hot air drying**Fig 6:** Moisture Ratio vs. Drying Time for sun drying

### Quality Evaluation of Honey Based Herbal Gooseberry Candies

The quality evaluation of honey based herbal gooseberry candies prepared by tray drying and traditional sun drying method was carried out on the basis of physical (dehydration

ratio), biochemical (i.e., non-enzymatic browning, ascorbic acid, total sugar and reducing sugar) and sensory evaluation (i.e., colour, flavour, taste, aroma, appearance and overall acceptability) as per the standard methods are reported in Table 5 and Table 6.

**Table 5:** Physical and biochemical parameters of hot air dried and sun dried gooseberry candies

Repli- cation	Physical parameter		Biochemical parameter							
	RR		NEB, OD		AA (mg/100 g)		TS (%)		RS (%)	
	HAD	SD	HAD	SD	HAD	SD	HAD	SD	HAD	SD
I	2.15	2.75	0.095	0.045	109.55	145.32	48.55	64.23	28.12	35.62
II	1.98	2.88	0.088	0.051	111.28	135.44	46.22	61.25	26.44	36.33
III	1.96	2.92	0.105	0.040	98.56	132.84	42.95	58.68	27.55	32.42
IV	2.05	3.11	0.092	0.047	115.25	140.66	47.23	61.87	29.11	33.47
V	1.85	2.80	0.087	0.049	105.68	139.65	40.50	63.55	25.64	37.85
Mean	2.00	2.89	0.09	0.05	108.06	138.78	45.09	61.92	27.37	35.14
S.D.(±)	0.11	0.14	0.01	0.00	6.33	4.83	3.30	2.18	1.37	2.19

HAD – Hot air drying; SD – Sun Drying; RR – Rehydration ratio; NEB – Non-enzymatic browning; AA – Ascorbic acid; TS – Total sugar; RS – Reducing sugar

**Table 6:** Sensory evaluation of hot air dried and sun dried gooseberry candies

Repli- cation	Sensory characters											
	Color		Flavor		Odor		Taste		Aroma		Overall acceptability	
	HAD	SD	HAD	SD	HAD	SD	HAD	SD	HAD	SD	HAD	SD
I	6.00	7.25	6.50	7.5	6.50	8.75	7.50	8.50	5.75	8.50	6.45	8.10
II	6.50	7.25	5.75	6.75	7.25	8.50	7.25	7.50	5.25	8.25	6.40	7.65
III	7.00	7.75	6.50	7.75	7.50	7.75	6.50	7.25	5.75	8.00	6.65	7.70
IV	6.25	8.50	6.25	8.25	5.75	8.25	5.75	6.75	5.50	7.75	5.90	7.90
V	7.25	7.75	6.75	8.00	7.00	8.00	6.75	7.00	5.00	7.50	6.55	7.65
VI	7.00	8.00	7.5	8.50	7.25	7.75	6.50	7.50	6.25	8.25	6.90	8.00
VII	5.75	8.25	7.25	7.50	6.25	8.50	6.75	6.75	6.00	8.00	6.40	7.80
VIII	7.50	7.00	6.50	7.25	7.00	7.75	6.50	7.75	5.75	8.25	6.65	7.60
IX	7.25	8.50	5.75	6.75	6.50	7.25	6.25	8.25	6.50	9.00	6.45	7.95
X	6.50	8.75	6.75	7.00	6.00	7.25	6.75	8.00	6.25	8.75	6.45	7.95
Mean	6.70	7.90	6.55	7.53	6.70	7.98	6.65	7.53	5.80	8.23	6.48	7.83
S.D.(±)	0.59	0.60	0.56	0.61	0.59	0.52	0.49	0.61	0.47	0.45	0.26	0.17

HAD – Hot air drying ; SD – Sun Drying

### Rehydration ratio

It was observed that (Table 5) the mean value of rehydration ratio (RR) was obtained 2.0 and 2.89 in hot air drying and sun drying, respectively. It indicated that value of rehydration ratio in sun drying was 1.45 times higher than that of tray drying. Thus, highest value of rehydration ratio in sun drying shows excellent water holding capacity of honey based herbal gooseberry candies as compared to hot air drying. This might be attributed to failure of intercellular porous structure in tray drying due to higher drying temperature of 60 °C. The collapse of intercellular structure of gooseberry candy results in poor water holding capacity, i.e., lower value of rehydration ratio.

### Non-enzymatic browning (NEB)

The mean values (Table 5) of non-enzymatic browning (NEB) was obtained 0.09 OD and 0.05 OD in hot air drying and sun drying, respectively. It indicated that value of non-enzymatic browning in hot air drying was 1.80 times higher than that of sun drying. Lower value of non-enzymatic browning in sun drying showed good color quality, i.e., less darkening of honey based herbal gooseberry candies as compared to hot air drying. This might be attributed to degradation of color pigments, volatile matter, polyphenols, vitamins, etc., of candies due to higher drying temperature of 60 °C in hot air drying. The degradation of these constituents resulted in poor color quality in hot air drying, i.e., higher value of non-enzymatic browning as compared to sun drying.

### Ascorbic acid content, total sugar and reducing

The lower mean values of ascorbic acid (AA), total sugar (TS) and reducing sugar (RS) of 108.78 mg/100 g, 45.09 % and 27.37 %, respectively, were obtained for gooseberry candies dried by hot air drying, while that's were higher in

sun drying of 138.78 mg/100 g, 61.92 % and 35.14 %, respectively. These indicated that higher retention of ascorbic acid, total sugar and reducing sugar, i.e., 1.27, 1.37 and 1.28 times respectively, in sun drying than that's of hot air drying. This might be attributed to loss of organic acid in hot air drying due to higher drying temperature of 60 °C. The thermal degradation of organic acid will result in lower value of ascorbic acid in hot air drying.

Also, thermal degradation of carbohydrate compounds, ultimately lower down retention of total sugar and reducing sugar. However, sun drying was carried out at ambient condition during 1<sup>st</sup> to 4<sup>th</sup> November, i.e., during these periods' maximum ambient temperature was 36.8 °C and wind air velocity was 2.85 km/h (0.78 m/s). These lower range of air temperature will lower the process of thermal degradation and results in better retention of biochemical parameters.

### Sensory evaluation of gooseberry candies

Higherscore of sensory attributes, viz., colour, flavour, odour, taste, aroma and overall acceptability were obtained 7.90, 7.53, 7.98, 7.53, 8.23 and 7.83, respectively, in sun dried candies. While, comparative lower score of colour, flavour, odour, taste, aroma and overall acceptability of 6.70, 6.55, 6.70, 6.65, 5.80, and 6.48, respectively, in hot air dried candies. Finally, overall acceptability of candies prepared by sun drying (7.83) was 1.20 times higher than that prepared by hot air drying (6.48).

### Conclusions

- Osmotic dehydration of 10 mm gooseberry segments in 60 °β concentration of osmotic solution (1:5 sucrose-honey) + 1:5 sample to solution ratio + 50 °C process temperature + 10 h immersion time, was found to be the best among all the other treatment combinations on the



basis of water loss to solid gain ratio (WL/SG) as an efficiency of osmotic dehydration.

- The hot air drying at 60 °C temperature and 2.5 m/s air velocity required 11 hours to reduce the initial moisture content of osmoted gooseberry segments from 60 % (wb) to 7-8 % (wb), whereas, sun drying required 36 hours (i.e., 4 days). So, hot air drying was 3.25 time faster than that of sun drying for drying of osmotically dehydrated segments.
- On the basis of overall quality analysis of honey based herbal gooseberry candies by the sun drying method was found to be the best on the basis of higher rehydration ratio (2.89), lower non-enzymatic browning (0.05 OD), higher ascorbic acid (138.78 mg/100 g), higher total sugar (61.92 %), higher reducing sugar (35.14 %) and higher overall acceptability (7.83) as compared to hot air drying.

## References

1. Anonymous. Horticultural statistics at a Glance - 2018, Horticulture Statistics Division, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfares, New Delhi.
2. Barthakur NN, Arnold NP. Chemical analysis of emblica (*phyllanthus emblica* L.) and its potential as a food source. *Sciencia Horticulturae*. 1991; 47(1/2):99-105.
3. Bawa AS, Gujral HS. Effect of osmotic agents on the drying behavior and product quality in raisin processing. *Journal of Scientific & Industrial Research*. 2000; (59):63-66.
4. Belewu MA, Belewu KY, Nkwunonwo CC. Effect of biological and chemical preservatives on the shelf life of west African soft cheese. *African Journal of Biotechnology*. 2005; 4(10):1076-1079.
5. Carocho M, Barros L, Barreira JCM, Calhella RC, Soković M. Basil as functional and preserving ingredient in "Serra da Estrela" cheese. *Food chemistry*. 2016; 207:51-59.
6. Garg G, Sharma S, Dua A, Mahajan R. Antibacterial potential of polyphenol rich methanol extract of Cardamom (*Amomum subulatum*). *Journal of Innovative Biology*. 2016; 3(1):271-275.
7. Goyal RK, Patil RT, Kingsly ARP, Walia H, Kumar P. Status of post harvest technology of aonla in India: A review. *American Journal of Food Technology*. 2008; (3):13-23.
8. Islam MN, Flink JM. Dehydration of potato. II. Osmotic concentration and its effect on air-drying behavior. *Journal of Food Technology*. 1982; 17:387-403.
9. Kalra CL. The chemistry and technology of aonla (*Phyllanthus emblica* L.) a resume, *Indian Food Packer*. 1988; 38(4):67-71.
10. Kamboj R, Bera MB, Nanda V. Mass transfer kinetic study of honey based apple preserve through osmotic dehydration. *Asian Journal of Chemistry*. 2017; 29(1):166-170
11. Kapoor IPS, Singh B, Singh G. Essential oil and oleoresins of cardamom (*Amomum Subulatum* roxb.) as natural food preservatives for sweet orange (*Citrus sinensis*) juice. *Journal of Food Process Engineering*. 2011; 34:1101-1113.
12. Kshirsagar VA. Studies on osmotic air drying characteristics of sapota slices. M.Tech. (Agril.Engg.) Thesis. Junagadh Agricultural University Junagadh (Gujarat), 2006.
13. Kumar P, Devi P. Optimization of some process variables in mass transfer kinetics of osmotic dehydration of pineapple slices. *International Food Research Journal*. 2011; 18:221-238.
14. Kumar S, Nath V. Storage stability of aonla fruits – A comparative study of zero energy cool chamber versus room temperature. *Journal of Food Science and Technology*. 1993; 30(3):202-203
15. Ranganna S. Handbook of Analysis and Quality Control for Fruits and Vegetable Products. 2<sup>nd</sup> edition. Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2010
16. Sadasivam S, Manickam A. Biochemical Methods. 2nd Ed. New Age International Private Ltd. Publishers, Coimbatore, India, 1996.
17. Sagar VR, Kumar PS. Involvement of some process variables in mass transfer kinetics of osmotic dehydration of mango slices and storage stability. *Journal of scientific and industrial research*. 2009; 68:1043-1048.
18. Singh S, Singh AK, Josh HK, Bagle BG, Dhandar DG. Evaluation of packages for transportation and storability of aonla (*Emblca officinalis*) under semi-arid environment of Western India. *Journal of Food Science and Technology*. 2009; 46:127-131.
19. Sethi K, Kaur M. *International Journal of Engineering and Adanced Technology*. 2019; 9(1):6257-6262.
20. Supreetha S, Mannur S, Simon SP, Jain J, Tikare S, Mahuli A. Antifungal activity of ginger extract on *Candida albicans*: An in-vitro study. *Journal of Dental Sciences and Research*. 2011; 2(2):1-5.
21. Tajkarim MM, Ibrahim SA, Cliver DO. Antimicrobial herb and spice compounds in food. *Food Control*. 2010; 21(9):1199-1218
22. Tandon DK, Yadav RC, Sood S, Kumar S, Dikshit A. Effect of blanching and lye peeling on the quality of aonla candy. *Indian Food Packer*. 2003; 57(6):147-149.
23. Tripathi VK, Singh MB, Singh S. Studies on comparative compositional changes in different preserved products of Amla (*Emblca officinalis Garten*) variety *Banarasi*. *Indian Food Packer*. 1988; 42(4):60-65.
24. Tyagi M, Dhawan SS. Development of osmotic dehydrated aonla (*Emblca officinalis, Gaertn*) *International Journal of Current Microbiology and Applied Sciences*. 2017; 6(11):1369-1374
25. Tyler VE. Herbs of choice: the therapeutic use of phytomedicinals. *Pharmaceutical Products Press*. 1994, New York
26. Udupa KN. Ayurveda for Promotion of Health. *Journal of Ayurveda*. 1985, 3.