Journal of Crop and Weed, 14(1): 111-116 (2018)

Drying characteristics of bitter gourd (*Momordica charantia*)

I. BISWAS, S. MANDAL, M. SAMADDER AND S. MUKHERJEE

Department of Post Harvest Engineering, Faculty of Agricultural Engineering, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741252, Nadia, West Bengal

Received : 01-11-2017 ; Revised : 12-03-2018 ; Accepted : 15-03-2018

ABSTRACT

Bitter gourd (Momordica charantia), a seasonal vegetable is a source of many essential nutrient and contain low energetic and anti-diabetic property. To increase the self-life, a drying operation was done by using hot air oven dryer at different thickness of fruit slice (3,6 and 9mm) and temperature (60 ,70 and 80°C). The sliced bitter gourds were treated by NaCl solution before drying and dried up to 5 per cent moisture content (MC) on dry basis (db) and grinded to powder for further experiment. The drying rate increases with increase of temperature and decrease of thickness whereas diffusion and activation energy increase with increase of temperature and thickness and they are significantly variable. The maximum value of diffusion coefficient, activation energy, ascorbic acid and the protein were found at 80°C and 9mm thickness (1.9149×10^{-9}(m^2 s^{-1}), 118.77 KJ kg-mol^{-1}, 77.65 mg100g^{-1} and 5.65% (d.b.)) and minimum at 60°C and 3mm (0.0085×10^{-9}(m^2 s^{-1}), 74.93 KJ kg-mol^{-1}, 17.65 mg 100g^{-1} and 3.77% (d.b.)). Losses of nutrients were non-significantly variable.

Keywords*: Ascorbic Acid, Bitter Gourd, Diffusion coefficient, Drying, Drying rate, *Momordica charantia

Bitter gourd (*Momordica charantia*) also known as 'balsam pear' or 'bitter melon' is extremely bitter and cause of bitterness is high amount of cucurbitacin- like alkaloid momordicineand triterpene glycosides. It is a tropical and subtropical vine with many medicinal value and it improves the digestion and helps to reduce the blood sugar level (kalra *et al.,*1988). Its widely grown in India, China, Africa and the Caribbean. In 2016-17, India has produced 1.11 million metric tons and total accounting area is 98000 (National Horticulture Board, 2016-17). There are two types of bitter gourd which grown during summer and rainy season: one that is oblong, pale green and grows to 20cm in length and the other is oval and dark green and measuring 10 cm. Bitter gourd is very low in calories and fat (dry bitter gourd content 0.5%, Kulkarni *et al.*, 2005) but full of precious nutrients like magnesium, zinc, phosphorus, iron, beta-carotene, calcium, potassium, folate (72 µg 100 g^{-1}), phyto-nutrient, polypeptide-P, insulin, charantin (increases glucose uptake and glycogen synthesis inside the cells of liver, muscle and adipose tissue). It also contains high dietary fiber, crude protein (dry bitter gourd content 27.88 ± 3.75% (Bakare *et al.*, 2010)) and vitamins like B1, B2, B3, C (84 mg 100 g^{-1} for green and 2022.56 mg 100 g^{-1} for dried bitter gourd (Goo *et al.*, 2016)). It reduces the incidence of neural tube defects in the newborn babies, the risk of cardiovascular diseases (Simon *et al.*, 1988). It also reduces several types of cancers (Howe *et al.*, 1990) like esophageal, pancreatic and lung cancer (Wargovich, 2000) by forming N-nitroso compounds in stomach andimmune system (Byers and Parry, 1992), Bitter gourd has long been used as medicine and as a medicinal plant, it has been used for treating various diseases like diabetes mellitus (Virdi *et al.*, 2003), cough, respiratory diseases, skin diseases, wounds. It helps to cleanse the liver and regenerate the liver cells and weight loss.

Because of its medicinal benefits its need to consume all over the year but it's a seasonal vegetable so preservation is required for consuming all over the year. This could be achieved by extending the shelf life either in the fresh form or in the processed form. As per as the preservation is considered, drying is the most widely used conventional method for lowering the water activity but it reduces the nutritional value. Sample was blanched with Alkaline as it preserved better color, texture and higher ascorbic acid than tap water blanched sample (Kharel and Khanal, 2002) and the samples were treated with 0.2% KMS with 1% sodium or 5% NaCl for 10 min (Kulkarni *et al.*, 2006) as ascorbic acid degradation rates during drying dependents on samples treatment before drying and drying temperature (Marûl *et al.*, 2007) for color and ascorbic acid conservation, and for preservation.

MATERIALS AND METHODS

Raw materials

Fresh bitter gourd was procured from the local 'Mohanpur' market, Mohanpur, Nadia, West Bengal with an average weight of 40±10 g and washed thoroughly and sorted.

Sample Preparation

Fresh bitter gourds were cut by knife into 3 , 6 and 9 mm thickness. The blanching treatment was done at 95°C by using 0.25% Potassium Meta bisulphite (KMS) for 5 minutes and 2%NaCl for 3 minutes. Followed by cooling, cooled at room temperature (27°C).

Email: samadderagril@gmail.com

Diffusion coefficient in dehydration

The rate of mass transfer was optimized by calculating the diffusion coefficient. Diffusion coefficient was determined by the following Fick's Law.

$$\frac{M-M_e}{M_o-M_e}=\frac{8}{\pi^2}\sum\frac{e^{-(2n-1)^2\times\pi^2\times\frac{Dt}{L^2}}}{(2n-1)^2} \quad (1)$$

Where,

M = moisture content,

M_e = equivalent moisture content,

M_o = initial moisture content,

D = diameter of materials,

L = thickness of materials,

t = time of drying.

For long time diffusion process only first term of the series in above equation is considered as all other terms becomes insignificant.

Hence, the expression became –

$$\frac{M-M_e}{M_o-M_e}=\frac{8}{\pi^2}\times e^{\pi^2\times\frac{Dt}{L^2}} \quad (2)$$

After simplifying the expression,

$$In\left(\frac{M-M_e}{M_o-M_e}\right)=In\left(\frac{8}{\pi^2}\right)-\frac{\pi^2 Dt}{L^2} \quad (3)$$

here, slope = ð^{2}D for a graph of ln(MR) vs. $\frac{t}{L^2}$.

Following the equation of straight line in Cartesian coordinate as, y = mx + c. Therefore, diffusion coefficient, $D=\frac{Slope}{\pi^2}$ (4)

Activation energy

The energy required to initiate diffusion at any substance can be indicated by activation energy. It is a function of diffusion coefficient and temperature, which can be expressed by the following Arrehenius equation-

$$D=D_0\times e^{\frac{E_Q}{RT}} \quad (5)$$

So, $ln\ (D) = ln\ (D_0) - \frac{E_Q}{RT}$ (6)

Where,

D = Effective Diffusion coefficient,

L = Slice Thickness,

Do = Diffusion coefficient in infinite temperature,

Ea = Activation Energy, R = Universal gas constant,

T = Temperature in K

Ascorbic acid calculation

Ascorbic acid was determined by the 2, 6-dichlorophenol indophenol (DCPIP) titration procedures as per the method of Casanas *et al.* (2002). One gram of fresh tissue was crushed with 20 ml of 4% oxalic acid in a mortar and pestle. The material was centrifuged at 10,000 rpm for 30 minutes. Ten ml of sample's aliquot and 10 of ml of 4% oxalic acid were taken in a conical flask and titrated against alkali solution with 2,6-dichlorophenol indophenol (DCPIP) dye (V2) until appearance of a faint pink color that persisted for a few minutes. Another 5 ml of 100 ppm solution of ascorbic acid and 10 ml of 4% oxalic acid were taken and titrated against DCPIP dye (V1). Amount of ascorbic acid was determined (mg 100 g^{-1}) by following the formula= (0.5×15× v_2× 100)/(8.5× v_1× 0.5)

Protein calculation

The concentration of total protein in dried and fresh bitter gourd samples were determined by Lowry Method by using BSA (BOVIEN SERUM ALBUMIN) as standard protein. The OD was measured by using spectrophotometer at 600nm. To calculate the amount of protein present in bitter gourd, a graph was established (Fig. 1) for standard value and took the Formula (**y = 0.016x + 0.003, R^2=0.906)** obtain from the graph.

Drying

The blanched bitter gourd slice of 3mm, 6 mm and 9mm were uniformly spread in a single layer on steel trays and dried at 60ÚC, 70ÚC, 80ÚC and 1.2 m/s air velocity in hot air dryer. The samples were weighed after every 15 minutes and drying was continued till the equivalent moisture level.

Preparation of bitter gourd powder

Bitter gourd powder was prepared by grinding the dried samples and continue pulverized till the whole sample passed through 50 micron sieves.

RESULTS AND DISCUSSION

Estimation of moisture content

The initial moisture content was found 1576.5 ± 271.1% (db) and the equilibrium moisture content 5.923%, 4.464% and 3.701% (db) at 60ºC, 70ºC and 80ºC temperature or further

Drying time

Sliced bitter gourd of different thickness were dried after treatment at different temperature (S1=9 mm thickness and 80p C, S2 = 6 mm thickness and 80p C, S3 = 3 mm thickness and 80p C, S4 = 9 mm thickness and 70p C, S5 = 6 mm thickness and 70p C, S6 = 3 mm thickness and 70p C, S7 = 9 mm thickness and 60p C,

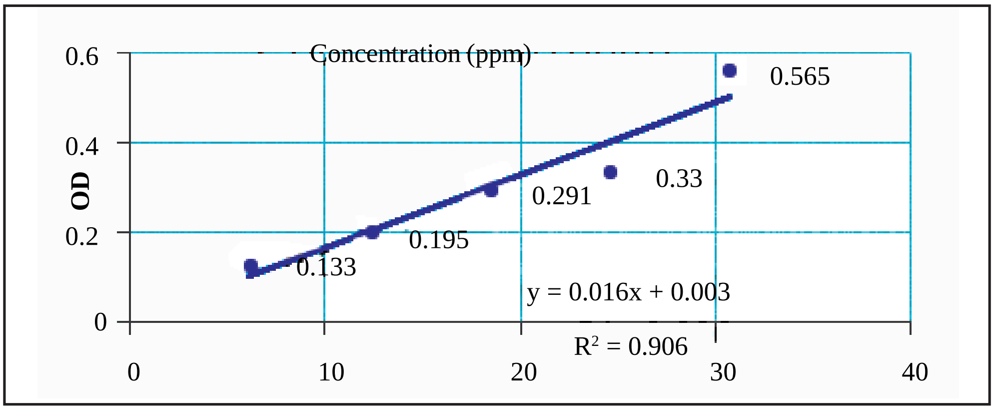

Fig. 1: Optical density versus concentration of standard protein.

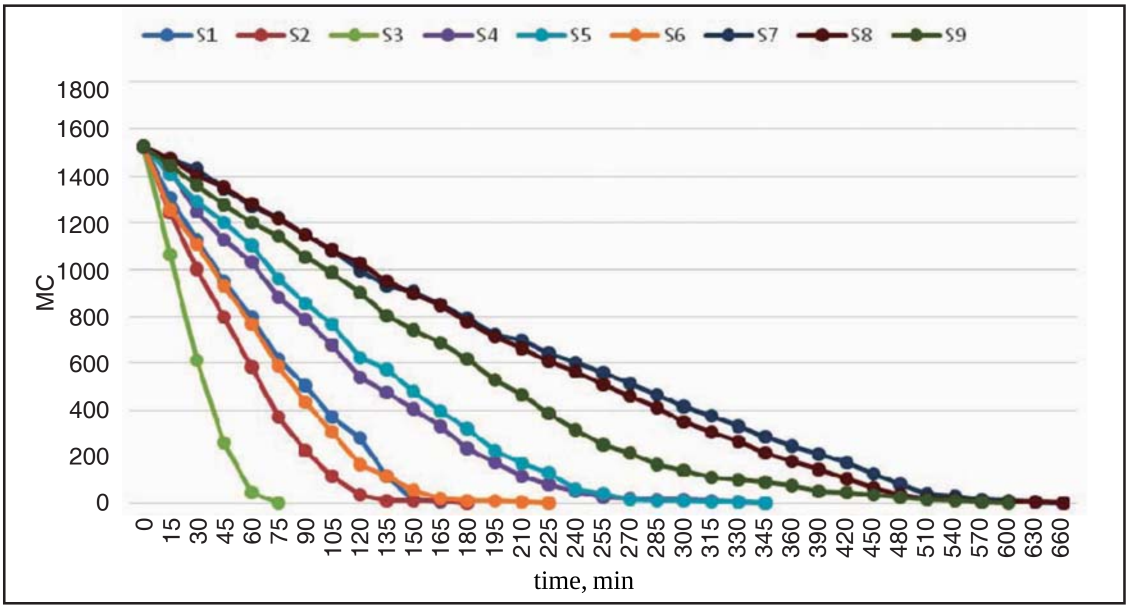

Fig. 2: Moisture content (db) of different thickness and temperature at different time of drying

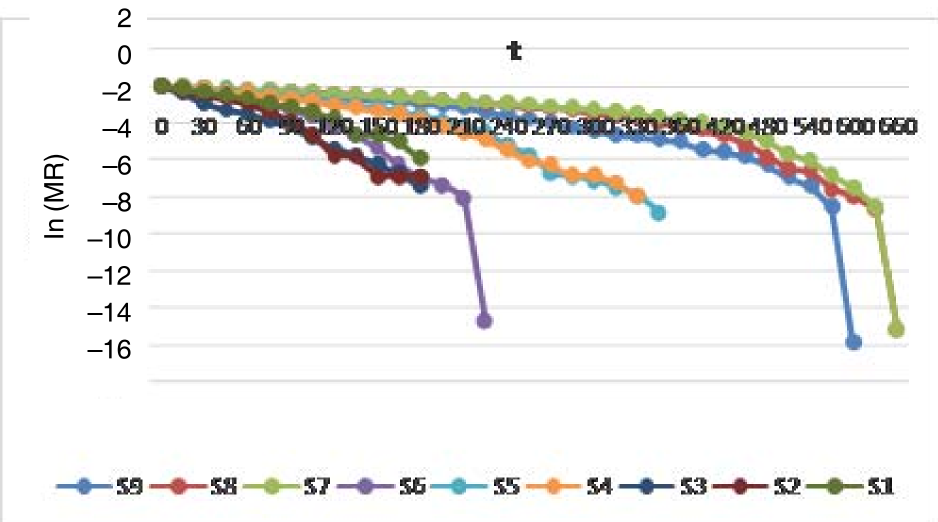

Fig. 3: ln(MR) vs time at different thickness and temperature

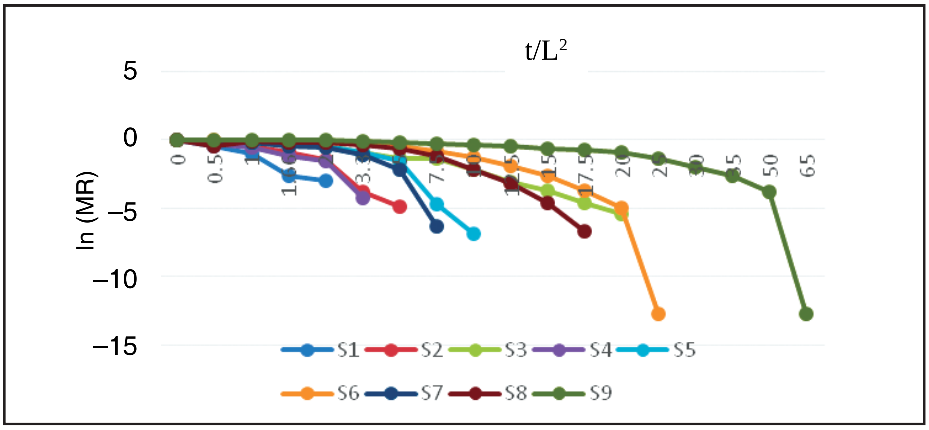

Fig. 4: ln(MR) vs t/L^2 graph at different thickness and temperature

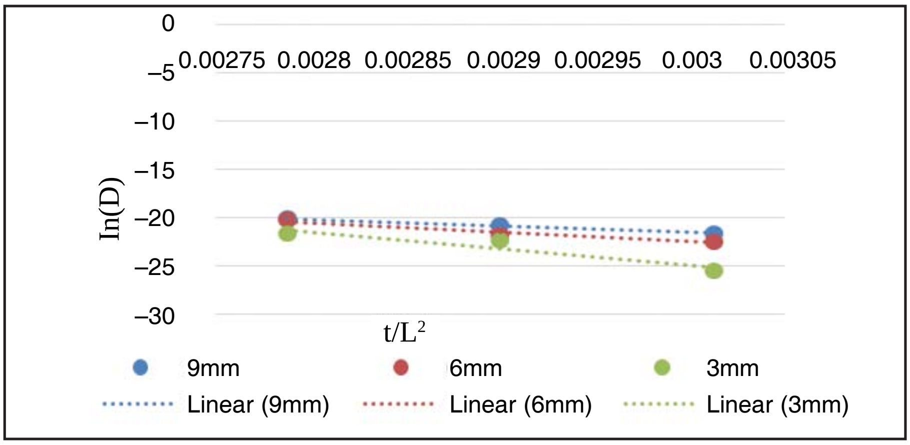

Fig. 5: Graph of ln(D) vs. $\frac{t}{L^2}$ of 9 mm thickness at different temperature

S8 = 6 mm thickness and 60p C, S9 = 3 mm thickness and 60p C). Drying time of S3 is less compare to other and achieved 5±0.2% MC (db). Initial reducing of MC is more and rate of reducing was decreased with time (Fig. 2). The curve was generally exponential in nature and did not fit in the first order exponentially, perhaps could be attributed to the fact that the diameter of capillary pores in bitter gourd slices decrease with the decrease in moisture content, causing blockage of the internal pores and shrinkage reduced the available surface area for moisture evaporation as drying progressed.

Drying rate constant

The value of drying rate constant (k) was determined by plotting ln(MR) with time (t) for all the drying experimental conditions like type of dryer, temperature and pressure. By using the slopes of the fig. 3, the values of drying rate constant were calculated (Table 4) by using the basic equation for thin layer drying as given by Hall and the value is 0.60 to 1.68. The value increase with the increase of temperature and decrease with the increase of thickness. Linear relationship equations among ln(MR), time and drying rate constant are shown in table 1.

Diffusion coefficient

Diffusion coefficients were determined by using the equations 3 and 4 at different thickness(L) and temperatures. The values of linear equation of diffusion coefficients were estimated from the slopes of the curves ln(MR) vs $t^{-1} L^2$ (Fig. 4), where "t" is time of drying in seconds. Table 1 shows the polynomial relationship equation and table 4 shows the values of diffusion coefficients. The value of diffusion coefficient varied from 0.0085×10^{-9} m^2 s^{-1} to 1.9149×10^{-9} m^2 s^{-1}. The value of diffusion coefficient increases with the increase of temperature and thickness and this result confirmed with Goyal *et al.*, 2015 and Ochoa-Martínez *et al.*, 2011.

Table 1: Relationship between drying characteristics time and thickness

Sample	Drying rate constant (k)	Diffusion coefficients
S1	y = -0.3087x + 0.7057R^2 = 0.9403	Y= -0.818X+1.0398R^2 = 0.9455
S2	y = -0.4793x + 1.0076R^2 = 0.9583	Y= -0.8125X+1.5617R^2 = 0.8489
S3	y = -0.4378x + 0.5702R^2 = 0.9893	Y= -0.4445X+1.2802R^2=0.9009
S4	y = -0.2709x + 1.0573R^2 = 0.9412	Y= -0.7361X+1.2603R^2=0.7772
S5	y = -0.2907x + 1.3323R^2 = 0.9076	Y= -0.7455X+1.0437R^2=0.6978
S6	y = -0.5948x + 2.1147R^2 = 0.7483	Y= -0.6161X+2.5202R^2=0.5685
S7	y = -0.1886x + 1.5112R^2 = 0.5708	Y= -0.6756X+1.6594R^2=0.6166
S8	y = -0.2074x + 1.6522R^2 = 0.6401	Y= -0.5086X+1.6455R^2=0.7366
S9	y = -0.2247x + 1.507R^2 = 0.6481	Y= -0.3619X+1.9655R^2=0.4137

Table 2: Polynomial relationship between ln(D) and time thickness^{-2}

	Activation energy
9mm	Y=-0.7663x-19.283, R^2=0.99
6mm	Y=-1.117x-19.213, R^2=0.96
3mm	Y=-1.919x-19.324, R^2=0.88

Table 3: Activation energy of drying

Sample thickness (mm)	Activation energy (KJ kg-mol^{-1})
9	118.711
6	108.73
3	74.93

Table 4: Chemical analysis bitter gourd powder and drying characteristics of bitter gourd

Sample	Protein content (%)	Ascorbic acid (db)(mg 100g^{-1})	Drying rate constant (k) (h^{-1})	Diffusion coefficient (D) (m^2 s^{-1})
S1	5.65	77.65	1.26	1.9149×10^{-9}
S2	7.54	60.00	1.64	1.7022×10^{-9}
S3	4.61	38.82	1.68	0.3951×10^{-9}
S4	4.89	45.88	0.96	0.9574×10^{-9}
S5	6.38	49.41	1.02	0.3675×10^{-9}
S6	4.13	38.82	1.68	0.1975×10^{-9}
S7	4.73	45.88	0.48	0.4136×10^{-9}
S8	4.01	38.82	0.54	0.1823×10^{-9}
S9	3.77	17.65	0.60	0.0085×10^{-9}

Activation energy

Activation energy was determined by using equation 6. The value of activation energy are 118.711, 108.73 and 74.93 KJ/kg-mol for sample thickness of 9, 6, and 3 mm respectively. The value increase with the increase of sample thickness. Table 3 shows the activation energy of drying and table 2 shows the polynomial equations relationship.

The biochemicals changes of bitter gourd powder also depended on the drying temperature and the thickness of drying. There is a significant change of ascorbic acid with the change of temperature and thickness of drying. Value of ascorbic acid varies from 17.65 to 77.65 mg/100 for S9 and S1 respectively. The result of ascorbic acid value was compared with the results described by Kandasamy *et al.*, 2014. Protein content percentage decreases as time of store increases for control conditions and comparably high temperature drying treatment (Bagchi *et al.*, 2014). Protein content also increase with the increase of drying temperature but decrease with the increase of drying thickness and also with the decrease of thickness protein content decrease. Best result showed 7.54 per cent for S2.

Drying of bitter gourd took place under the falling rate period. The moisture content reduced initially at a faster rate which gradually decreased with time. Rate of moisture loss increase with increase of drying temperature and decreases with increase slice thickness. The optimum product quality could be obtained by hot air tray drying of green bitter gourd slices with the pre-treatment condition (0.2% KMS and 3.5 min blanching time) for 9 mm thickness and drying temperature of 80ÚC on the basis of protein and ascorbic acid retention.

REFERENCES

A.O.A.C. 1999. *Official Methods of Analysis*, 15th edn. Association of the Official Analytical Chemists, Washington, DC.

Bagchi, T. B., Adak, T. and Chattopadhyay, K. 2014. Process standardization for rice bran stabilization and its' nutritive value. *J.Crop Weed*, **10**(2):303-307.

Bakare, R. I., Magbagbeola, O. A., Akinwande, A. I. and Okunowo, O. W. 2010. Nutritional and chemical evaluation of *Momordica charantia*. *J. Medicinal Pl. Res.* **4**(21): 2189-93.

Byers, T. and Perry, G. 1992. Dietary carotenes, Vitamin C, and Vitamin E as protective antioxidents in human cancers. *Ann. Rev. Nutri.* **12**: 139-59.

Casanas, R., Gonzalez, M., Rodriguez, E., Marrero, A. and Diaz, C. 2002. Chemo metric studies of chemical compounds in free cultivars of potatoes from Tenerife. *J.Agric. Food Chem.* **50**(7): 2076-82.

Goo, K. S., Ashari, S., Arifin, N. B. and Sugiharto, N. 2016. The bitter gourd (*Momordica charantia L.):* morphological aspects, charantin and vitamin C contents. *J. Agric. Vete. Sci.* **9**(10):76-81.

Goyal, S., Kumar, M. and Mahajan, B. V. C. 2015. Thin layer drying kinetics of potato mash. *Agric Res. J.* **52** (4):80-86.

Kandasamy, P., Varadharaju, N., Kalemulla, S. and Maladhi, D 2014. Optimization of process parameters for foam-mat drying of papaya pulp. *J. Food Sci. Tech.* **51**(10) : 2526-34.

Kalra, C. L, Berry, S. K. and Kulkarni, S. G. 1988. The bitter gourd-A unique vegetable. *Indian Food Packer,* **42**(2) : 35-45.

Kharel, G. P. and Khanal, D. 2002. Drying optimization and storage stability of bitter gourd (*Momordica charantia L.*). *Nepal J. Sci. Tech.* **4**:83-86.

Kulkarni, C., Kulkarni, K. S. and Hamsa, B.R. 2005.l-Glutamic acid and glutamine: exciting molecules of clinical interest. *Indian J Pharmacology,* **37**(3): 148-54.

Kumar, S.S., Kalra, R. and Nath, N. 1991. Dehydration of bitter gourd (Momordica charantia Linn) rings. *J. Food Sci. Tech.* **28**(1): 52-53.

Marûl, P.H.M., Santos, E. M. and Telis, V. R. N. 2007. Ascorbic acid degradation kinetics in tomatoes at different drying conditions. *Food Sci. Tech.* **41** : 1642-47.

National Horticulture Board (2016-17). nhb.gov.in

Ochoa-Martínez, C. I., Quintero, P. T., Ayala, A. A. and Ortiz, M. J. 2011. Drying characteristics of mango slices using the refractance Window™ technique. *J. Food Engg*. **109**:69–75.

Simon, J. P., Hudes, E. S. and Brown, W. S.1988. Serum ascorbic acid and cardiovascular disease prevalence in US adults. *Epidemiology*, **9** : 316-21.

Singh, U., Sagar, V. R., Behera, T. K. and Kumar, S. P. 2006. Effect of drying conditions on the quality of dehydrated selected leafy vegetables. *J. Food Sci. Technol.* **43**(6) : 579-82.

Virdi, J., Sivakami, S., Shahani, S., Suthar, A. C. and Banavalikar, M. M. 2003. Anti-hyperglycemic effects of three extracts from *Momordica charantia. J. Ethnopharmacology,* **88**(1) : 107-11.

Wargovich, M. J. 2000. Anticancer properties of fruit and vegetables. *Hort. Sci.* **35**:573-75.

Li, X., Long, Q., Gao, F. N., Han, C., Jin, P., and Zheng, Y. 2017. Effect of cutting styles on quality and antioxidant activity in fresh-cut pitaya fruit. *Post Harvest Biol. Tech.* **12**(4):1-7.