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Effect of Drying Methods on Proximates, Sensorial Quality and Shelf Life of Dehydrated Bitter Gourd

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ABSTRACT: In context to combat basic health ailments Bitter gourd is a good source of vitamin C, catechin, gallic acid, epicatechin, and chlorogenic acid, too powerful antioxidant compounds that can help protect your cells against damage. For which dehydrated Bitter gourd was prepared using two drying methods i.e. cabinet and sun drying. Pretreatments like steam blanching and hot water blanching, different preservatives such as KMS, NaCl and Vinegar were used. The shelf life studies of dried bitter gourd were packed in plastic container and paper laminated with aluminium foil and stored for 90 days in ambient temperature. On the basis of experimental trials, it was found that, Cabinet drying gave better result as compared to sun drying. Whereas the treatment T7 (hot water blanching for 96°C for 3 min and dip in KMS solution (0.2%) for 5 min) was found to be best treatment then other treatment, after 90 days of storage period in paper laminate with aluminium foil packaging material found to be best under ambient condition. Hence dehydrated bitter gourd has the potential to become an important value added product because of relatively inexpensive, easily and quickly coockable and rich in several nutrients, which are essential for human health.

Keywords: Bitter gourd, dehydration, sun drying, cabinet drying, rings and shelf life.

INTRODUCTION

Bitter gourd (*Momordica charantia* L.) the Cucurbitaceous fruit commonly known as *Karela* in India (Bhattacharjee *et al*., 2016). It is a tropical and subtropical vine with much medicinal value and it improves the digestion and helps to reduce the blood sugar level (Kalra *et al*. 1988).

It is very low in calories (17 calories per 100g) but dense with precious nutrients. It is an excellent source of vitamins B complex, vitamin C, proteins, magnesium, folic acid, iron, zinc, phosphorus, manganese, and has high dietary fibre and many other nutrients required in the human diet which are necessary for maintaining proper health (Keding and Krawinkel, 2006).

Drying of product is a complex combination of heat and mass transfer processes, which depends on external parameters such as temperature, humidity and velocity of the air stream; drying material properties of the agricultural products such as surface characteristics rough or smooth surface, chemical composition, physical structure porosity, density (Baradey *et al*., 2016).

Reducing moisture content of foodstuff down to a certain level slows down the action of enzymes, bacteria, yeasts and molds (Srinivasan and Balusamy 2015).

Pre-treatments play an important role in permeabilisation, enzyme inactivation, oxidation, and acceleration of drying rate in many fruits and vegetables. Bitter gourds were pre-treated with different methods such as hot water blanching, steam blanching, microwave blanching and chemical dipping. These pre-treatments highly affect the other quality parameters such as vitamin C, 2, 2-diphenyl-1-picrylhydrazyl (DPPH) and ferric reducing antioxidant power. Water blanching involves uniform heating by exposing vegetables to a temperature range of 70–100 C for 1 or 2 min (Arroqui *et al*. 2001).

Sun drying is performed by sun or solar heat, assisted by movement of surrounding air. To be successful, it demands a rainless season of bright sunshine and temperatures above 98°F coinciding with the period of product maturity (Brennand, 1994).

Cabinet drier may run up to 25 trays high and operate with air temperature of about 95°C (dry bulb) and with air velocities of about 2.5-5 m/sec across the trays. They commonly are used to dry fruit and vegetable pieces, and depending on the food and the desired final moisture, drying time may be of the order of 10 or even 20 hours (Srivastava and Sanjeev 2002).

Dehydrated products are hygroscopic in nature and exchange between food product and its surrounding atmosphere is a common problem. These changes can be controlled by providing adequate packaging material (Sagar, 2001). Hence, in the light of the above observations this research work was formulated on to see the effect of drying methods on nutritional quality and shelf life of dehydrated Bitter Gourd.

MATERIAL METHODS

Experimental site: Department of Food Science and Technology, Plant Physiology, COA, JNKVV Jabalpur (M.P.). **Experimental Materials:** *Raw material, Preservative and Packaging material* were obtained from local market of Jabalpur. **Experimental details**:- *Treatments*: - 1. Steam blanching and dipping in KMS solution, NaCl solution and Vinegar. 2. Hot water blanching and dipping in

KMS solution, NaCl solution, and Vinegar. *Drying methods*: - Two drying methods denoted as D1- Sun drying and D2- Cabinet drying was used.

Table 1: Treatment combination with detailed.

S.No.	Combinations	Drying methods	Details
1.	T0	T0D1, T0D2	Control
2.	T1	T1D1, T1D2	Steam blanching for 3 min
3.	T2	T2D1, T2D2	Steam blanching for 3 min+dip in KMS solution (0.2%) for 5 min
4.	T3	T3D1, T3D2	Steam blanching for 3 min+dip in KMS solution (0.5%) for 5 min
5.	T4	T4D1, T4D2	Steam blanching for 3 min +dip in 5% NaCl solution for 5 min.
6.	T5	T5D1, T5D2	Steam blanching for 3 min+dip in vinegar for 5 min.
7.	T6	T6D1, T6D2	Hot water blanching for 96°C for 3 min.
8.	T7	T7D1, T7D2	Hot water blanching for 96°C for 3 min+dip in KMS solution (0.2%) for 5 min.
9.	T8	T8D1, T8D2	Hot water blanching for 96°C for 3 min+dip in KMS solution (0.5%) for 5 min.
10.	T9	T9D1, T9D2	Hot water blanching for 96°C for 3 min+dip in 5% NaCl solution for 5 min.
11.	T10	T10D1, T10D2	Hot water blanching for 96°C for 3 min+dip in vinegar for 5 min.

D_1- Sun dryingandD_2- Cabinet drying

Preparation of dehydrated Bitter gourd product (slices and grated):- *Selection of fruit*: - Raw, disease free, fresh bitter gourd fruit were selected for the drying.
Washing:-The selected bitter gourd were washed thoroughly using clean and safe water to remove foreign matter and dust.
Cutting and grating: - The bitter gourds were cut into 1 cm thick rings with the help of a sharp stainless steel knife and they were grated with help of grater. *Blanching*: - Steam blanching: - The prepared rings and grated bitter gourd were blanched in steam for 3 minutes. The gas stove was used to boil the water and the temperature was maintained. Each time 150gm of sample was taken into stainless steel sieve.
Hot water blanching: - The samples were blanched in boiling water at 96°C for 3 minutes. The gas stove was used to boil the water and the temperature was maintained. Each time 250gm of sample was taken into muslin cloth and dipped into boiling water for 3 min.
Dipping in solution:- The sample were dipped in different solutions such as KMS solution (0.2, 0.5%) NaCl solution (5%) and Vinegar for 5 min.
Drying: - Only two drying methods sun drying and cabinet drying was used in our thesis work).
D1- Sun drying: - Pretreated and fresh bitter gourd slices and grated (chopped) were sun dried for 6-7 hours for 3 to 4 days till it dried completely. 5-6% moisture reduced from dehydrated bitter gourd samples, and then dried samples were cooled and packed in different packaging materials.
D2- Cabinet drying: - Pretreated and fresh bitter gourd product (slices and chopped) were dried in cabinet dryer for 7-8 hours till it dried completely. The temperature for drying was taken as 55°C. During dehydration process, the moisture contents were recorded for an interval of half an hour to two hours. Final moisture content was reduced to 5-6%.
Sensory evaluation of dehydrated bitter gourd products: - The sensory evaluation of dried bitter gourd products was done as described by Amerine *et al.*, (1967) on 9 point hedonic scale.
Storage studies- All samples were drawn periodically after 0, 30, 60, 90 days and analyzed for sensory qualities, moisture, microbial count and hunter colour analysis. The total plate count was done by using the method of Aneja, (2003).
Physico-chemical methods:-*Physical parameters of dried bitter gourd*:- *Hunter color values*:- Color measurement of dehydrated bitter gourd was done by using a Hunter colour measuring system and expressed in terms of L, a, b, according to the CIE method (1976). *Dehydration and Rehydration ratio*:-Drying ratio was calculated as net dry weight obtained from fresh weight of the material (Ranganna, 2002). Yield of dried product (gm):- A known quantity of fresh bitter gourd was dried by different drying methods and then weight.

Table 2: Physical properties of fresh bitter gourd.

S.No.	Parameters	Amount	
		Ring	Grated(chopped)
1.	Thickness	1cm	0.5cm
2.	Weight	100g	100g
3.	Hunter colour value L* a* b*	58.30 4.95 21.25	

Chemical parameters of dried bitter gourd: - *Moisture*: - The moisture content of the sample was determined by using moisture meter. *Protein, total carbohydrate percentage, fat, total crude fibre and ash:* - were estimated by the hydrolysis method as described in AOAC (2002).
Ascorbic acid (Vitamin C):- The ascorbic acid content was estimated as method given by Ranganna (2002). *Total Phenolic Content (TPC):-* The total phenolic content was determined by using Folin-Ciocalteu reagent following a slightly modified method of Ainsworth and Gillespie (2007). *Total Chlorophyll Content (Acetone Method):-*Total Chlorophyll Content can be estimated by acetone extraction method (Yoshida *et al*., 1976). *Total Carotenoid Content (Acetone Method*):- Total Carotenoid Content can be estimated by acetone extraction method (Yoshida *et al*., 1976). *Chlorophyll retention*: - Chlorophyll is a major coloring pigment in bitter gourd. Total chlorophyll content was determined by the method of Hiscox and Israelstam (1979).

Minerals Content (Iron and Zinc) estimation:-Iron and Zinc in the above acid digest were determined by Atomic Absorption Spectrophotometer described by Black, (1965).
Microbial examination: - The total microbial count of stored products was done by Downes and Ito (2001).

Table 3: Chemical properties of fresh bitter gourd.

S.No.	Parameters	Amount
1.	Moisture	89.64%
2.	Protein	1.60%
3.	Carbohydrates	4.20%
4.	Fat	0.20%
5.	Crude fibre	1.7%
6.	Ash	7.36%
7.	Vitamin C	77.56 mg/100g
8.	Total phenolic content	6.89 mg of GAE/100g
9.	Total chlorophyll	11.23 mg/100g
10.	Total carotenoids	2.16 mg/100g
11.	Chlorophyll retention	19.24mg/100g
12.	Iron	0.43mg/100g
13.	Zinc	0.80mg/100g

RESULTS AND DISCUSSION

Physical and chemical components of fresh bitter gourd: - The result showed that physical properties of fresh bitter gourd had Thickness of ring (1cm) and grated (0.5cm), weight 100g in both, Hunter colour value L* 58.30, a* 4.95, b* 21.25 and chemical properties had Moisture 89.64%, Protein 1.60%, Carbohydrates 4.20%, Fat 0.20%, Crude fibre 1.7%, Ash 7.36%, Vitamin C 77.56 mg/100g, Total phenolic content 13.28 GAE/g, Total chlorophyll 11.23 mg/100g, Total carotenoids 2.16mg/100g, Chlorophyll retention 1.24mg/100g, Iron 0.43mg, Zinc 0.80mg respectively.
Effects of drying methods on physical properties of dehydrated bitter gourd: - *Hunter colour analysis of dehydrated bitter gourd: - 'L' values:* - which found to be in the range of 54.32 to 65.91. Generally, the lightness increased from the processing variable D1T4 (54.32) (steam blanching + 5% NaCl solution in sun drying) to D2T7 (65.91) (hot water blanching+0.2% KMS solution) in cabinet drying shown in Table 4. *'a' Values:*-The a value of dehydrated bitter gourd ranged from 3.34 to 6.85. (Table 4). Maximum 'a' value in the treatment D2T7 (6.85) in cabinet drying and minimum was in the treatment D1T4 (3.34) in sun drying. *'b' values:* - The 'b' value for dehydrated bitter gourd ranged from 19.27 to 27.25 (Table4.2a). The 'b' value of dehydrated bitter gourd was highest in the treatments D1T4 (27.27) in sun drying and lowest value was in the treatment D2T7 (19.27) in cabinet drying.

Table 4: Hunter colour analysis of dehydrated bitter gourd.

Treatment	D1			D2		
	L*	a*	b*	L*	a*	b*
T0	62.89	3.75	20.87	62.25	6.17	23.52
T1	56.93	3.36	22.57	60.86	5.28	26.02
T2	61.57	3.50	22.14	60.83	3.71	27.13
T3	60.51	3.43	26.85	60.66	3.54	26.23
T4	54.32	3.34	27.27	58.35	5.89	25.19
T5	58.30	3.42	22.94	59.29	3.48	25.29
T6	61.79	4.36	21.38	62.58	4.66	24.85
T7	63.80	6.27	20.57	65.91	6.85	19.27
T8	63.55	6.11	21.87	63.66	4.50	25.68
T9	62.13	4.65	21.13	61.26	4.22	24.79
T10	60.49	4.72	21.35	61.44	4.74	26.88

(L- Lightness, a- Redness and greenness, b- Yellowness and blueness) (D1 – Sun drying and D2- Cabinet drying)

Dehydration ratio: - The maximum dehydration ratio was found in treatment T4 (10.98) whereas minimum was found in T0 (10.30) in sun drying respectively. The higher value was at par with treatment T5. In case of cabinet drying the higher value was found in T4 (9.90) and minimum was found in T7 (9.17) respectively. All the combination was found non-significant difference. **Rehydration ratio: -** Dehydrated bitter gourd made from difference processing variable viz. Drying methods, (sun drying and cabinet drying) and different treatments. The larger value of rehydration ratio is the desirable characteristic of the dehydrated bitter gourd. The Table 4.2b showed that, the highest rehydration ratio was found in the treatment T7 (5.74) whereas lowest value was found in the treatment T4 (4.09) in sun drying. All treatment was found non-significant difference except T3, T4 and T5. In cabinet drying highest ratio was found in the treatment T7 (5.92) and lowest was found in the treatment T4 (5.18). Significant difference was found in all treatment.
Yield of dried product (gm):- The yield of dehydrated bitter gourd subjected to different pre-treatment prior to drying is given in Table 5. The maximum yield was found in the treatment T7 (9.70gm) whereas lowest value was found in the treatment T4 (9.10gm) in sun drying. The higher value was at par with the treatment, except T2 and T7. In case cabinet drying the maximum yield was found in the treatment T7 (10.92gm) whereas lowest value in treatment T4 (10.10gm). Significant difference was found in all treatment.
Shrinkage (%):- Shrinkage is important drying characteristics used to specify quality of dried products. The minimum shrinkage percentage was the desirable characteristic of the dehydrated bitter gourd. Shrinkage of dehydrated bitter gourd rings in different drying methods (sun drying and cabinet drying) and in treatments was presented in Table 5, The maximum ratio was found in the

treatment T4 (51.55%) whereas lowest value was found in the treatment T7 (45.58%) in sun drying. All treatment combination showed significant difference among each other. In cabinet drying the maximum was found in the treatment T4 (50.33%) whereas lowest value was found in the treatment T7 (44.05%). Significant difference was found in all treatment.

Table 5: Effects of drying methods on physical properties of dehydrated bitter gourd.

Treatment	Dehydration ratio		Rehydration Ratio		Yield of dried Product (gm)		Shrinkage (%)	
	D1	D2	D1	D2	D1	D2	D1	D2
T0	10.30	9.43	5.42	5.44	9.60	10.60	50.71	44.32
T1	10.66	9.80	5.11	5.42	9.40	10.21	50.48	47.71
T2	10.47	9.70	5.21	5.58	9.55	10.30	50.41	48.71
T3	10.52	9.65	4.19	5.54	9.50	10.36	51.14	47.05
T4	10.98	9.90	4.09	5.18	9.10	10.10	51.55	50.33
T5	10.86	9.80	4.49	5.66	9.20	10.20	49.67	48.23
T6	10.60	9.34	5.60	5.73	9.40	10.71	46.74	46.03
T7	10.41	9.17	5.74	5.92	9.70	10.92	45.58	44.05
T8	10.52	9.25	5.58	5.77	9.50	10.80	46.31	45.45
T9	10.73	9.61	5.26	5.43	9.30	10.40	51.42	48.35
T10	10.50	9.34	5.51	5.77	9.50	10.76	48.53	45.41
SEm±	0.05	0.006	0.25	0.02	0.05	0.036	0.448	0.78
CD@5%	0.173	0.017	0.701	0.049	0.170	0.107	1.322	2.324

(D1 – Sun drying and D2- Cabinet drying)

Effects of drying methods on chemical composition of dehydrated bitter gourd:

*Moisture:-*The Table 6 showed that, the moisture content varied from 4.30 to 5.75%. The maximum moisture content was found in the treatment T4 (5.75%) whereas lowest value was found in the treatment T7 (5.20%) in sun drying. The higher value was at par with treatment, except T0, T1 and T7. The maximum was found in the treatment T4 (4.71%) whereas lowest value was found in the treatment T7 (4.30%) under cabinet drying. Non- significant difference was found in all treatment.

Protein: - The Table 6 showed that, the value of protein content of dehydrated bitter gourd ranged from 19.37 to 22.59% in both the drying methods. Maximum protein content was found in the treatment T7 (21.86%) and (22.59%) in sun and cabinet drying, whereas the minimum was found in T4 (18.42%) and T5 (19.37%). All the treatments and drying methods showed significant difference among each other.

Total carbohydrates: - As the data showed in table 6.The total carbohydrates value of dehydrated bitter gourd ranged from 50.20 to 54.60% in drying methods. Maximum was found in the treatment T7 (53.46%) whereas minimum was found in the treatment T5 (50.20%) in sun drying. In cabinet drying maximum was found in the T7 (54.60%) whereas minimum was found in the treatment T5 (51.21%). Total carbohydrates were statically at par in all treatments in both drying method. *Fat content:* - As evident from Table 6. The fat content of dehydrated bitter gourd ranged from 1.30 to 3.86% in sun and cabinet drying methods. Maximum content was found in the treatment T8 (2.66%) and T7 (3.86%) in sun and cabinet drying, whereas the minimum was found in T4 (1.30%) and (2.25%). All the treatments and drying methods showed significant difference among each other.

Table 6: Effects of drying methods on chemical composition of dehydrated bitter gourd.

Treatment	Moisture (%)		Protein (%)		Total Carbohydrates (%)		Fat (%)		Crude fibre (%)		Ash (%)	
	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2
T0	5.22	4.37	21.00	21.20	52.61	53.43	1.60	2.26	13.70	13.03	6.75	6.83
T1	5.34	4.31	19.70	21.68	51.70	53.94	1.56	2.90	11.40	11.56	6.96	6.73
T2	5.43	4.64	19.75	20.60	51.46	54.04	1.53	2.40	11.16	12.93	6.78	6.80
T3	5.63	4.47	19.54	21.55	51.42	53.38	1.60	2.76	11.56	11.86	6.86	7.03
T4	5.75	4.71	18.42	20.99	50.33	53.83	1.30	2.25	11.06	11.13	6.26	6.86
T5	5.70	4.36	19.54	19.37	50.20	51.21	1.60	2.90	11.63	12.53	7.50	7.63
T6	5.55	4.49	20.32	21.07	52.86	51.36	2.53	3.30	11.76	12.51	7.00	7.96
T7	5.20	4.30	21.86	22.59	53.46	54.60	2.33	3.86	13.76	14.33	7.76	8.33
T8	5.58	4.52	21.77	21.67	52.31	52.55	2.66	3.20	11.63	13.73	7.43	8.30
T9	5.64	4.43	21.57	20.51	52.23	54.92	2.33	2.96	12.86	13.20	7.56	7.76
T10	5.69	4.63	21.24	20.50	52.62	54.51	1.34	3.03	11.46	13.40	7.43	7.90
SEm±	0.117	0.225	0.836	1.522	0.565	0.678	0.136	0.258	0.661	0.873	0.341	0.438
CD@5%	0.346	0.664	0.283	0.516	1.668	2.002	0.402	0.762	1.951	1.822	1.006	1.291

(D1 – Sun drying and D2- Cabinet drying)

*Crude fibre:-*The highest fibre content was found in the treatment T7 (13.76%) whereas lowest value was found in the treatment T4 (11.06%) in sun drying. Significant difference was found in all treatment. Table4.3a. In cabinet drying highest was found in the treatment T7 (14.33%) and lowest was found in the treatment T4 (11.13%). All treatment was found non- significant difference except T1, T3 and T4.

*Ash:-*It is obvious from the Table 4.3b that, the higher ash content was found in the treatment T7 (7.76%) whereas minimum was found in T4 (6.26%) under sun drying. Non- significant difference was found in all treatment. In case of cabinet drying maximum

content was found in T7 (8.33%) and the lowest T1 (6.73%).The higher value was at par with treatment, except T0, T1, T2 and T7. *Vitamin C:* - The data presented in Table 7 that, the maximum vitamin c content was found in the treatment T7 (52.45mg) and (56.34mg) in sun and cabinet drying, whereas the minimum was found in T4 (45.27mg) and (49.82mg). All the treatments and drying methods showed significant difference among each other.

Total phenolic content:-As the data showed that in Table 4.3b. The total phenolic content was ranged from 7.40 to 10.48 mg of GAE/100g. Maximum content was found in the treatment T7 (8.76 mg of GAE/100g) whereas minimum was found in the T4 (7.40 mg of GAE/100g) sun drying. The higher value was at par with treatment, except T2, T4 and T5.

In cabinet drying maximum content was found in the treatment T7 (10.48 mg of GAE/100g) whereas minimum was found in the treatment T4 (9.32 mg of GAE/100g). All the treatment combination showed significant difference among each other.

Total chlorophyll:-Result indicated (Table 7) that the maximum content was found in the treatment T7 (11.76mg) and (12.73mg) in sun and cabinet drying, whereas the minimum was found in T4 (9.85mg) and (10.38mg). All treatments and drying methods were having significant difference among each other. *Total carotenoids:*-It is evident from the data presented in (Table 7) that, total Carotenoid content ranged from 1.14 to 2.84mg. The maximum was found in the treatment T7 (1.92mg) whereas minimum was found in T4 (1.14mg) in sun drying. All treatment combination was statically at par with each other. In cabinet drying maximum value was found in the treatment T7 (2.84mg) whereas minimum was found in T5 (1.52mg). The higher value was at par with treatment, except T1, T2, T3, T4 and T5.

Table 7: Effects of drying methods on chemical composition of dehydrated bitter gourd.

Treatment	Vitamin C (mg)		Total phenolic Content (mg)		Total chlorophyll(mg)		Total carotenoids (mg)		Chlorophyll retention (mg)		Iron (mg)		Zinc (mg)	
	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2
T0	45.61	51.07	8.35	9.84	11.37	11.48	1.67	2.48	18.51	19.72	5.67	5.28	16.24	16.30
T1	46.57	52.12	8.40	9.40	10.19	10.53	1.42	2.22	16.39	19.28	5.04	5.31	16.22	16.40
T2	46.54	50.28	7.82	9.77	10.86	11.34	1.51	1.60	17.57	19.65	5.19	5.80	16.19	16.53
T3	46.47	51.15	8.39	9.56	10.20	10.94	1.48	1.55	17.79	18.62	5.44	5.54	16.25	16.26
T4	45.27	49.82	7.40	9.32	9.85	10.38	1.41	1.56	16.16	17.22	5.24	5.55	16.18	16.60
T5	45.60	55.85	7.53	9.81	10.42	10.52	1.54	1.52	17.72	18.37	5.18	5.28	16.47	16.66
T6	46.95	51.21	8.50	9.65	10.63	11.85	1.51	2.53	17.55	19.78	5.25	5.73	16.34	16.50
T7	52.45	56.34	8.76	10.48	11.76	12.73	1.92	2.84	18.59	20.45	5.56	5.85	16.53	16.87
T8	51.52	54.53	8.36	9.51	11.39	11.44	1.66	2.76	18.34	19.95	5.54	5.53	16.46	16.76
T9	46.57	50.86	8.60	9.56	10.24	11.05	1.49	2.44	16.57	19.88	5.44	5.64	16.30	16.32
T10	48.48	52.57	8.46	9.78	10.58	10.96	1.62	2.77	17.08	20.35	5.45	5.56	16.40	16.61
SEm±	0.571	0.495	0.144	0.150	0.363	0.480	0.176	0.173	0.521	0.499	0.111	0.013	0.091	0.082
CD@5%	1.685	1.460	0.424	0.441	1.072	1.416	0.519	0.509	1.537	1.474	0.328	0.039	0.268	0.241

(D1 – Sun drying and D2- Cabinet drying)

Chlorophyll retention:-The chlorophyll retention value of dehydrated bitter gourd ranged from 16.16 to 20.45mg/100g in both drying methods. Maximum was found in the treatment T7 (18.59 mg) whereas minimum was found in the treatment T4 (16.16 mg) in sun drying. The higher value was at par with treatment, except T1, T4 and T9. In cabinet drying maximum was found in the T7 (20.45 mg) whereas minimum was found in the treatment T4 (17.22 mg) the higher value was at par with treatment, except T3, T4 and T5 as shown in Table 7.

Minerals: - *Iron:*-The data presented in Table 4.3b indicated that the iron content ranged from the 5.18 to 5.85mg. The maximum content was found in the treatment T7 (5.85mg) in cabinet drying. Minimum was found in T5 (5.18) in the sun drying. Iron content statically at par with each other in both drying methods. *Zinc:* It is obvious from the Table 7 that the zinc content ranged from the16.18 to 16.87mg. The maximum was found in the treatment T7 (16.87mg) in cabinet drying. Minimum was found in T4 (16.18) in the sun drying. Zinc content statically at par with each other in both drying methods.

Effects of drying methods on sensory attributes of dehydrated bitter gourd: Before introducing a food product in the market, it should undergo sensory evaluation test to show their acceptability. ***Sensory attributes of dehydrated bitter gourd (Rings)****:- Colour and appearance:*-The result revealed in Table 8 that, the all processing variable was non- significant. The highest score was found in the treatment T7 (8.78) in cabinet drying. In sun drying T4 treatment got the lowest score (6.05) for colour and appearance.

Texture:-The result indicate that, the highest score was found in the treatment T7 (8.97) in cabinet drying and lowest score was found in T4 (8.08) sun drying for texture (Table 8).

Flavour:-An appraisal of Table 8 that, the maximum flavour was found in T9 (7.94) and minimum in T5 (7.06) under cabinet and sun drying respectively. *Taste:*-The data depicted in Table 8 showed that, the treatment T9 (8.67) in cabinet drying score maximum value whereas the T5 (6.18) in sun drying got the minimum score for taste. *Overall acceptability:*- Overall acceptability was determined on the basis of quality scores obtained from the evaluation of colour and appearance, texture, flavour and taste of the dehydrated bitter gourd are shown in Table 8 revealed that, the treatment T7 (7.94) was highest score in cabinet drying where as lowest was found in T4 (7.02) in sun drying.

Table 8: Sensory attributes of dehydrated bitter gourd (Rings).

Treatment	Sun drying					Cabinet drying				
	Colour	Texture	Flavour	Taste	Overall	Colour	Texture	Flavour	Taste	Overall
T0	7.72	8.33	7.80	7.02	7.22	8.25	8.54	7.84	7.61	7.73
T1	6.24	8.57	7.25	6.78	7.54	7.42	8.27	7.48	6.88	6.78
T2	6.44	8.53	7.45	7.44	7.76	7.40	8.37	7.57	6.45	7.63
T3	6.64	8.88	7.15	7.36	7.78	8.73	8.16	7.28	7.37	7.26
T4	6.05	8.08	7.34	8.33	7.02	6.64	8.13	7.54	8.42	7.11
T5	6.14	8.16	7.06	6.18	7.26	7.70	8.23	7.15	6.25	7.35
T6	7.54	8.23	7.37	7.62	7.57	8.56	8.78	7.38	7.65	7.69
T7	7.78	8.89	7.55	7.14	7.92	8.78	8.97	7.38	8.22	7.94
T8	7.43	8.67	7.40	8.27	7.43	8.31	8.55	7.23	8.44	7.66
T9	6.58	8.76	7.91	8.67	7.82	8.75	8.44	7.94	8.67	7.72
T10	6.68	8.62	7.14	7.22	7.73	8.54	8.75	7.45	7.95	7.75
Sem±	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
CD@5%	0.019	0.017	0.017	0.018	0.017	0.017	0.018	0.017	0.018	0.018

Storage stability: - *Shelf life study of dehydrated bitter gourd product (Rings and grated)*:- The storage trials were conducted for 90 days at ambient temperature in two packaging material i.e. Plastic container (PVC)-P1 and Paper laminated with aluminium foil (PAF)-P2 were used in the study. Out of 11 treatments, the best treatment combination (T7 Hot water blanching for 960c for 3 min and dip in KMS solution (0.2%) for 5 min.) in both the drying methods were selected by the penal of judges. These selected treatments (P1D1T7) (P2D1T7) (P1D2T7) (P2D2T7) and control (P1D1T0) (P2D1T0) (P1D2T0) (P2D2T0) were analyzed periodically after 0, 30, 60 and 90 days for moisture content, sensory evaluation and microbial count. The findings of quality parameters studied for shelf life of the product.

Table 9: Sensory attributes of dehydrated bitter gourd (Grated).

Treatment	Sun drying					Cabinet drying				
	Colour	Texture	Flavour	Taste	Overall	Colour	Texture	Flavour	Taste	Overall
T0	7.70	7.29	7.12	7.00	7.12	7.43	7.31	7.16	7.60	7.56
T1	6.14	7.13	7.20	6.13	6.70	7.35	7.45	7.26	6.85	6.72
T2	6.36	7.40	7.13	6.12	7.14	7.38	7.46	7.23	6.15	7.56
T3	6.32	7.55	7.10	7.17	7.02	7.16	7.57	7.28	7.54	7.23
T4	6.01	7.06	7.23	7.14	6.43	7.66	7.16	7.31	7.67	7.03
T5	6.13	7.33	7.00	6.46	7.25	7.98	7.36	7.44	7.02	7.55
T6	6.12	7.56	7.28	7.55	7.16	8.44	7.67	7.52	7.14	7.56
T7	7.70	7.79	7.11	7.70	7.00	8.77	7.88	7.36	7.72	7.90
T8	7.40	7.22	7.05	7.96	7.32	8.02	7.75	7.70	7.67	7.57
T9	6.23	7.14	7.82	8.84	7.69	8.66	7.15	7.93	8.16	7.71
T10	6.58	7.17	7.11	7.14	7.23	8.21	7.57	7.12	7.94	7.64
Sem±	0.019	0.006	0.006	0.006	0.006	0.032	0.006	0.006	0.102	0.006
CD@5%	0.056	0.017	0.018	0.018	0.017	0.095	0.017	0.019	0.302	0.019

Effects of drying methods on moisture content of dehydrated bitter gourd products during storage: - *Dehydrated bitter gourd rings:*-Result indicated that the moisture content was observed to increase during storage in both the packaging material. The change of moisture content of dehydrated bitter gourd rings showed in Table 10 the data revealed that the highest moisture content was found in the treatment P1D1T0 had an initial value of 5.70% which was gradually increase up to (5.90%) at the end of storage. Whereas lowest moisture content was found in the treatment P2D2T7 (hot water blanching for 96°C for 3 min and dip in KMS solution (0.2%) for 5 min) in cabinet drying had an initial value of 4.30% which was gradually increase up to (4.38%) at the end of storage.

Table 10: Moisture content of dehydrated bitter gourd rings during storage.

Treatment	Moisture (%)			
	0 days	30 days	60 days	90 days
P1D1T0	5.70	5.74	5.81	5.90
P2D1T0	5.70	5.71	5.76	5.80
P1D1T7	5.22	5.27	5.32	5.40
P2D1T7	5.22	5.25	5.28	5.31
P1D2T0	4.37	4.40	4.45	4.50
P2D2T0	4.37	4.39	4.41	4.44
P1D2T7	4.30	4.33	4.37	4.42
P2D2T7	4.30	4.31	4.34	4.38

(P1- Plastic container, P2- Paper laminated with aluminium foil, D1- Sun drying, D2- Cabinet drying,
T0- Control, T7- Hot water blanching for 960c for 3 min and dip in KMS solution (0.2%) for 5 min.)

Dehydrated grated bitter gourd:-The change of moisture content of dehydrated grated bitter gourd showed in Table 11 the data revealed that the highest moisture content was found in the treatment P1D1T0 had an initial value of 5.62% which was gradually increase up to (5.87%) at the end of storage. Whereas lowest moisture content was found in the treatment P2D2T7 (hot water

blanching for 96°C for 3 min and dip in KMS solution (0.2%) for 5 min) in cabinet drying had an initial value of 4.29% which was gradually increase up to (4.36%) at the end of storage.

Table 11: Moisture content of dehydrated grated bitter gourd during storage.

Treatment	Moisture (%)			
	0 days	30 days	60 days	90 days
P1D1T0	5.62	5.70	5.76	5.87
P2D1T0	5.62	5.69	5.73	5.79
P1D1T7	5.19	5.25	5.30	5.37
P2D1T7	5.19	5.23	5.27	5.30
P1D2T0	4.30	4.37	4.42	4.48
P2D2T0	4.30	4.33	4.39	4.43
P1D2T7	4.29	4.33	4.34	4.38
P2D2T7	4.29	4.30	4.32	4.36

(P1- Plastic container, P2- Paper laminated with aluminium foil, D1- Sun drying, D2- Cabinet drying,
T0- Control, T7- Hot water blanching for 960c for 3 min and dip in KMS solution (0.2%) for 5 min.)

Effects of drying methods on Overall acceptability of dehydrated bitter gourd products during storage: - *Overall acceptability of dehydrated bitter gourd (Rings):-* Mean score value of overall acceptability of dehydrated bitter gourd ring is presented in Table 12.

Table 12: Effects of drying methods on Overall acceptability of dehydrated bitter gourd ring during storage.

Treatment	Dehydrated bitter gourd (Rings)			
	0 days	30 days	60days	90 days
P1D1T0	7.22	7.10	6.93	6.81
P2D1T0	7.22	7.15	6.90	6.87
P1D1T7	7.92	7.63	7.44	7.21
P2D1T7	7.92	7.77	7.60	7.45
P1D2T0	7.73	7.65	7.21	7.11
P2D2T0	7.73	7.60	7.32	7.28
P1D2T7	7.94	7.80	7.67	7.56
P2D2T7	7.94	7.82	7.77	7.60

(P1- Plastic container, P2- Paper laminated with aluminium foil, D1- Sun drying, D2- Cabinet drying,
T0- Control, T7- Hot water blanching for 960c for 3 min and dip in KMS solution (0.2%) for 5 min.)

At 0 days of storage the maximum score of overall acceptability of dehydrated bitter gourd ring was found to be (7.94) in P1D2T7 and P2D2T7 where as minimum was found P1D1T0 (6.81) at 90 days of storage. The results further showed that overall acceptability of dehydrated bitter gourd rings was decreased with increase in the storage period. *Overall acceptability of dehydrated bitter gourd (Grated):-* The data on the changes in the overall acceptability score of dehydrated bitter gourd grated as influenced the storage period are increased. The data regarding the overall acceptability of dehydrated grated bitter gourd is presented in Table 13 that at 0days of storage the highest value of overall acceptability was found in the (7.90) in P1D2T7 and P2D2T7 where as minimum was found P1D1T0 (6.66) after 90 days of storage. The results further showed that overall acceptability of dehydrated bitter gourd grated was decreased with increase in the storage period.

Table 13: Effects of drying methods on Overall acceptability of dehydrated grated bitter gourd during storage.

Treatment	Dehydrated bitter gourd (Grated)			
	0 days	30 days	60 days	90 days
P1D1T0	7.01	6.88	6.71	6.66
P2D1T0	7.01	6.93	6.85	6.75
P1D1T7	7.12	7.03	6.73	6.65
P2D1T7	7.12	7.08	6.84	6.72
P1D2T0	7.56	7.44	7.36	7.29
P2D2T0	7.56	7.48	7.40	7.35
P1D2T7	7.90	7.87	8.73	8.51
P2D2T7	7.90	7.88	8.80	8.74

(P1- Plastic container, P2- Paper laminated with aluminium foil, D1- Sun drying, D2- Cabinet drying,
T0- Control, T7- Hot water blanching for 960c for 3 min and dip in KMS solution (0.2%) for 5 min.)

Table 14: Total plate count of dehydrated bitter gourd during storage.

Treatment	Microbial count			
	0 days	30 days	60days	90 days
P1D1T0	Nil	Nil	Nil	Nil
P2D1T0	Nil	Nil	Nil	Nil
P1D1T7	Nil	Nil	Nil	Nil
P2D1T7	Nil	Nil	Nil	Nil
P1D2T0	Nil	Nil	Nil	Nil
P2D2T0	Nil	Nil	Nil	Nil
P1D2T7	Nil	Nil	Nil	Nil
P2D2T7	Nil	Nil	Nil	Nil

(P1- Plastic container, P2- Paper laminated with aluminium foil, D1- Sun drying, D2- Cabinet drying, T0- Control, T7- Hot water blanching for 960c for 3 min and dip in KMS solution (0.2%) for 5 min.)

CONCLUSION

From the current study it was concluded that the bitter gourd is an excellent source of vitamins B complex, vitamin C etc. are necessary for maintaining proper health. The maximum dehydration ratio and shrinkage was found in treatment T_4 (10.98) and (51.55) in sun drying whereas minimum was found in T_7 (9.17) and (44.05) in cabinet drying. The highest rehydration ratio was found in the treatment T_7 (5.92) cabinet drying and lowest rehydration ratio was found in the treatment T_4 (4.09) sun drying. Maximum yield was found in the treatment T_7 (10.92) in cabinet drying and minimum yield was found in the treatment T_4 (9.10) in sun drying. The maximum moisture content was found in the treatment T_4 (5.75%) in sun drying and the minimum was found in T_7 (4.30%) under cabinet drying. On the basis of sensory evaluation overall acceptability was found in cabinet drying as compared to sun drying. Shelf life of dehydrated bitter gourd products found increased in the moisture content and decreased in overall acceptability during storage in both of packaging material i.e., Plastic container and Paper laminated with aluminium foil.

FUTURE SCOPE

The drying will impart to make available the nutritious and hygienic bitter gourd products around the year and anywhere in entire country.

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