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GM Waghmare
Department of Horticulture
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

AM Bhosale
Department of Horticulture
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

BM Kalalbandi
Department of Horticulture
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

AK Padole
Department of Horticulture
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Correspondence
GM Waghmare
Department of Horticulture
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Effect of drying methods on nutritional and qualitative composition of bitter gourd (*Momordica charantia* L.) under Parbhani

GM Waghmare, AM Bhosale, BM Kalalbandi and AK Padole

Abstract
The results of present investigation indicated that chemical pre-treatment, T_6 ($MgCo_3$-0.25%) dried under cabinet drying was found superior in maintaining minimum moisture, drying ratio, dehydration ratio, while maximum rehydration ratio, vitamin A, vitamin C, iron, phosphorus thought the storage periods. However, the T_1 (control) treatment had registered the maximum moisture, drying ratio, dehydration ratio whereas minimum rehydration ratio, vitamin C, vitamin A, Phosphorus, iron. In case of the dehydration methods, the cabinet drying was found to be superior in maintaining the lower percent of moisture, drying ratio, dehydration ratio, higher percent of rehydration ratio, vitamin C, vitamin A, phosphorus and iron used for the preparation of drying of bitter gourd slices. Interaction effect treatment combination consisting of T_5D_2 ($MgCo_3$-25%+ cabinet drying) stood superior for all above parameters followed by ($MgCo_3$-0.25% + cabinet drying) (D_2T_6).

Keywords: Effect drying methods nutritional, qualitative composition bitter gourd

Introduction
The post-harvest losses of bitter gourd are about 25 per cent. Main reason for these much loss is due to ripening and mechanical damage during transport. Bitter gourd fruit is used as vegetable in many ways and are quite commonly used in cooked, stuffed, fried form. The fruit are also pickled, canned and dehydrated. The preservation methods such as dehydration, steeping (salt solution) and pickling can be successfully adopted to preserve bitter gourd for off-season. In the recent past, there has been an increasing demand for value added products, during the peak season of production there is always is tendency of market glut leading to slump in price. Therefore, processing of these vegetables is essential and there is demand for processed products is desirable. The present study was undertaken to develop simple technology for drying and dehydration of bitter gourd.

Materials and methods
The present investigation entitled "Studies on effect drying methods on nutritional and qualitative composition of bitter gourd (*Momordica charantia* L.)" was conducted at Department of Horticulture of VNMKV Parbhani. The p experiment was conducted in factorial randomized block design consisting twenty one treatment combination, consisting of three levels drying methods(cabinet drying, solar drying and sun drying) and seven levels of pre-treatment viz, KMS-0.1%,(T_1), KMS-0.2% (T_2), Salt-1.5% (T_3), Salt-2% (T_4), $MgCo_3$-0.20% (T_5), $MgCo_3$-0.25% (T_6) and T_7 (control) and dried in cabinet(D_2), solar(D_3) and sun drying(D_1) using local variety. An observation on physio-chemical composition of dried bitter gourd were studied- Drying time (Rangana, 1986) [5], Drying rate (Singh and Sagar, 2013) [7], Drying ratio (Rangana, 1986) [5], Dehydration ratio (Shah *et al*., 2007) [6], Rehydration ratio (Singh and Sagar, 2013) [7], Vitamin C (Rangana, 1966) [4], Phosphorus (Rangana, 1925) [3], Iron (Rangana, 1928), and Moisture % (Venkatesan and Arjunan, 2014) The data obtained in respect of various observations were subjected to the statistical analysis (Randomized Complete Block Design as per the procedure given by Steel and Torie (1980) Arjuna9n.

Results
Drying time (hrs)
Perusal of data presented in Table 1 revealed that minimum time (10.40 hrs), required for the

T_7-untreaed (control) sample while the maximum drying time (12.15 hrs) was required for drying the slices treated under T_6 - 0.25% $MgCo_3$ followed by T_5 – 0.20% $MgCo_3$ (18.57 hrs).The least time taken for drying may be due to the nature of the chemical and efficacy of drying method to remove moisture content in unit time. Similar observation reported by Adarsh k. *et al*. (2001) in onion. The cabinet drying (D_2) required minimum time (3.40 hrs) as compared to solar drying D_3- (11.36 hrs) and sun drying D_1- (16.45 hrs) for drying of bitter gourd slices. The interaction effect between the pre-treatment and drying methods were found statistically significant. The treatment combination D_1 T_6 – sun drying x $MgCo_3$-0.25% recorded maximum (18.65 hrs) time for drying, while the treatment combination D_2 T_7-Cabinet drying x untreated (control) recorded minimum (3.40 hrs) drying time. Lesser number of hours taken for drying in cabinet drier might be due to higher and constant drying temperature of 60^0 C as compared to a temperature of 30 to 33^0 C maintained in surrounding atmosphere. Similar results were reported by Srinivasan and Balusamy (2015) [10] and Hiremath (2010).

Table 1: Effect of pre-treatment and drying methods on rehydration ratio

Treatment	Drying time			Drying rate			Drying ratio			Dehydration ratio			Rehydration ratio		
	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
T_1 (0.1% KMS)	17.87	4.05	12.86	0.9	1.6	1.3	12.0	8.8	10.7	6.9	3.0	4.9	4.96	6.50	5.92
T_2 (0.2% KMS)	17.83	3.55	12.83	0.9	1.4	0.6	11.4	7.6	9.4	7.1	3.1	5.1	5.41	6.66	6.35
T_3 (1.5% salt)	17.20	3.45	12.21	0.7	1.4	1.4	10.1	8.8	10.4	7.5	2.6	5.0	5.47	6.84	6.42
T_4 (2% salt)	17.35	3.50	12.36	0.9	1.5	1.4	11.1	7.8	9.6	7.9	2.8	5.4	5.51	6.88	6.48
T_5 (0.20%$MgCo_3$)	18.57	4.11	13.57	1.0	1.7	1.3	13.0	9.2	10.3	8.5	3.5	4.5	4.36	6.47	5.41
T_6 (0.25% $MgCo_3$)	18.65	4.15	13.64	1.2	1.8	1.4	13.8	9.6	10.3	8.8	4.2	6.1	4.81	6.64	5.78
T_7 (control)	16.45	3.40	11.36	0.9	1.4	1.4	9.1	7.1	8.4	9.1	4.7	6.6	4.33	5.87	5.25
SE(m)+(T)	0.08			0.07			0.21			0.09			0.003		
CD at 5%	0.25			0.43			0.64			0.27			0.010		
SE+(D)	0.05			0.05			0.14			0.06			0.002		
CD at 5%	0.16			0.14			0.42			0.18			0.006		
SE+(D X T)	0.01			0.13			0.37			0.16			0.006		
CD at 5 %	0.04			0.39			1.11			0.48			0.010		

Drying rate

It was observed that the sample pretreated with treatment, T_7 (control) showed higher drying rate and typical drying curve. The sample pre-treated with Salt 1.5 % (T_3) showed lower drying rate and typical drying curve. It was observed that drying rate was faster in cabinet drying (D_2) (1.8) as compared to solar (D_3) (1.4) and sun drying (D_1) (1.2). It is due to the cabinet drying required minimum time to reach the constant weight as compared to solar and sun drying. Interactions effect showed highest value (1.8) cabinet drying with control pretreatment (D_2T_7). And lowest drying rate was observed in sun dried sample (0.7) with pre-treatment 1.5% salt (D_1T_3). Present finding are in accordance with the earlier findings of Singh and Sagar (2013) [7] in bitter gourd

Drying ratio

Significantly highest drying ratio was recorded in pre-treatment T_6 $MgCo_3$-0.25 % (11.28), and lowest in untreated (control) (8.2).There were significant differences between the drying methods, irrespective of pre-treatment significantly highest drying ratio was recorded in sun drying D_1 (9.1) as compare to solar drying D_3 (8.4) and cabinet drying D_2 (7.1). The treatment combination D_1T_6 (sun drying x $MgCo_3$-0.25%) recorded maximum (13.85) drying ratio while the treatment combination D_2T_7 (Cabinet drying x control) (7.1) recorded minimum drying ratio. Drying ratio is minimum in cabinet as compare to solar and sun drying it is might be due to faster removal of moisture from the dried bitter gourd and net dry weight obtained is minimum as compare to sun and solar drying.

Dehydration ratio

The data reveals that, significantly lowest dehydration ratio in T_3 salt 1.5 % (5.03%) and highest dehydration ratio was recorded in pre-treatment T_7 control (6.83). Significantly lowest dehydration ratio was recorded in cabinet drying D_2 (4.75) as compared to solar drying D_3 (6.6) and sun drying D_1 (9.15). Cabinet drier was found better for obtaining better dehydration. The superiority of cabinet drier might be due to the presence of high temperature, low RH and constant airflow as compare to solar and sun drying. Highest dehydration ratio was found in bitter gourd slices blanched without treatment and lowest in bitter gourd slices blanched with salt solution. Highest dehydration ratio in the treatment combination D_1T_7 –sun drying x control (9.15) and lowest in D_2T_1- cabinet drying x KMS-0.1% (3.0).

Rehydration ratio

Significantly lowest rehydration ratio was recorded in pre-treatment T_7 (untreated) (5.15) and highest in T_4- salt-2% (6.29). In drying methods, significantly highest rehydration ratio was recorded in cabinet drying-D_2 (5.87) as compare to solar drying D_3- (5.25) and in sun drying-D_1 (4.33). The treatment combination D_2T_4 – cabinet drying x Salt 2% (6.88) recorded maximum rehydration ratio while the treatment combination D_1T_7-sun drying x untreated (control) (4.33) recorded minimum rehydration ratio. The rehydration ratio was higher in the product dehydrated in cabinet drier was due to faster removal of water during drying, lesser disturbances to anatomical structure of the fruit. While rehydration ratio was comparatively poor in sun drying sample due to maintenance and fluctuation in air flow and loss of texture. The present study is in accordance with Dhotre *et al*.(2012).

Vitamin A

At 90 days of storage the highest vitamin A (0.47 IU) was noticed in the pretreatment T_6 i.e.$MgCo_3$ samples and was significantly superior(Table 2).. However, the lowest vitamin

A (0.34 IU) was noticed in the pretreatment i.e. untreated (control). The observations recorded from 30, 60 days irrespective of methods of drying showed that biter gourd slices dried by cabinet dryer (D_2) notified maximum vitamin A as compare to solar (D_3) and sun drying (D_1) method upto 90 day of storage. The observations recorded from 30, 60 days irrespective of treatment combination showed that biter gourd slices dried by cabinet dryer (D_2) and pre-treated with 0.25 % $MgCo_3$ notified maximum vitamin A and lowest in sun dried sample without pretreated (control) sample upto 90 day of storage. The similar results were reported by Naikwade (2014) [2].

Table 2: Effect of storage period on vitamin A content of dried bitter gourd

Treatment	Vitamin A mg/100g											
	Storage periods											
	0			30			60			90		
	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
T_1 (0.1% KMS)	0.34	0.82	0.51	0.30	0.78	0.44	0.24	0.74	0.43	0.21	0.69	0.38
T_2 (0.2% KMS)	0.32	0.84	0.54	0.28	0.74	0.47	0.26	0.76	0.46	0.19	0.71	0.41
T_3 (1.5% salt)	0.29	0.74	0.48	0.22	0.70	0.44	0.18	0.66	0.40	0.13	0.61	0.38
T_4 (2% salt)	0.26	0.78	0.51	0.25	0.72	0.50	0.21	0.70	0.43	0.16	0.65	0.35
T_5 (0.20%$MgCo_3$)	0.35	0.86	0.59	0.31	0.80	0.55	0.27	0.78	0.51	0.22	0.73	0.46
T_6 (0.25% $MgCo_3$)	0.37	0.87	0.61	0.33	0.83	0.57	0.29	0.79	0.53	0.24	0.74	0.48
T_7 (control)	0.24	0.71	0.45	0.20	0.67	0.41	0.16	0.63	0.37	0.11	0.58	0.32
SE(m)+(T)	0.003			0.003			0.003			0.003		
CD at 5%	0.009			0.009			0.009			0.009		
SE+(D)	0.002			0.002			0.002			0.002		
CD at 5%	0.006			0.006			0.006			0.006		
SE+(D X T)	0.005			0.005			0.005			0.005		
CD at 5 %	0.016			0.016			0.016			0.016		

Vitamin C

The better retention of ascorbic acid was observed significantly higher treatment D_2T_6 (blanching with $MgCo_3$-0.25% + cabinet drying) followed by D_2T_5 (blanching with $MgCo_3$-0.20% + cabinet drying) and hence ascorbic acid retention was better in $MgCo_3$ (Table 3). The loss of ascorbic acid higher in the sun drier as compare to solar and cabinet drying. This is might be due to the proportional of moisture content and dry matter in the finished product, which might have affected the ascorbic acid in different drying condition Ascorbic acid is very sensitive to heat it might be lost due to application of heat during drying. The maximum loss of ascorbic acid content observed in control sample. These results are in good agreement with the result reported by Kulkarni *et al*., (2009) [2].

Table 3: Effect of storage period on Vitamin C content of dried bitter gourd

Treatment	Vitamin C mg/100g											
	Storage periods											
	0			30			60			90		
	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
T_1 (0.1% KMS)	26.15	54.64	34.25	25.75	54.57	34.20	25.35	54.53	34.16	24.95	53.95	34.12
T_2 (0.2% KMS)	29.45	55.65	35.45	29.05	55.61	35.05	28.65	55.57	34.65	28.25	55.53	34.25
T_3 (1.5% salt)	25.00	43.51	32.55	24.60	43.15	32.15	24.10	42.75	31.75	24.65	42.35	31.35
T_4 (2% salt)	25.85	44.28	34.24	25.45	43.75	32.95	25.5	43.35	32.55	23.65	42.95	32.15
T_5 (0.20%$MgCo_3$)	26.15	54.63	34.25	30.65	55.65	40.7	30.25	55.25	40.3	29.85	54.85	39.9
T_6 (0.25% $MgCo_3$)	29.45	55.64	35.45	31.35	62.00	41.9	30.95	61.6	41.5	30.55	61.2	41.1
T_7 (control)	24.85	41.25	30.18	24.45	40.75	30.14	24.00	40.35	30.10	23.7	39.95	29.75
SE(m)+(T)	0.58			0.83			0.83			0.83		
CD at 5%	1.71			2.46			2.46			2.45		
SE+(D)	0.37			0.54			0.54			0.54		
CD at 5%	1.12			1.61			1.61			1.60		
SE+(D X T)	1.004			1.44			1.44			1.44		
CD at 5 %	2.96			4.26			4.26			4.25		

Phosphorous

Perusal of data presented in Table 4 revealed that the phosphorous content was also affected by the storage period with advancement in the storage upto 90 days of storage, there was gradual decrease in the phosphorous content in drying methods irrespective of pretreatment during storage it was observed that significantly highest phosphorous content was recorded in cabinet drying as compare to solar and sun dried sample. The better retention of phosphorous content was observed significantly higher in treatment combination D_1T_6 (sun drying + $MgCo_3$-0.25%). Better retention of phosphorous in sun dried sample compare to solar and cabinet drying. Similar results reported by Venkatesan and Arjunan (2014).

Table 4: Effect of storage period on phosphorous content of dried bitter gourd

Treatment	Phosphrous mg/100g											
	Storage periods											
	0			30			60			90		
	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
T_1 (0.1% KMS)	559.23	360.15	460.22	559.19	360.11	460.18	559.14	360.06	460.13	559.08	360.00	460.07
T_2 (0.2% KMS)	560.23	361.21	461.24	560.20	361.17	461.20	560.15	361.12	461.15	560.09	361.06	461.09
T_3 (1.5% salt)	545.15	345.10	446.11	545.11	345.06	446.07	545.06	345.01	446.02	545.00	344.95	445.96
T_4 (2% salt)	545.18	345.13	446.13	545.14	345.09	446.09	545.09	345.04	446.04	545.03	344.9	445.98
T_5 (0.20%$MgCo_{3)}$	662.50	454.15	545.24	662.46	454.11	545.20	662.41	454.06	545.15	662.35	454.00	545.09
T_6 (0.25% $MgCo_3$)	663.16	454.18	545.28	663.12	454.24	545.24	663.07	454.19	545.19	663.01	454.13	545.13
T_7 (control)	542.17	340.28	441.18	542.13	340.24	441.14	542.08	340.19	441.09	542.02	340.13	441.03
SE(m)+(T)	0.05			0.05			0.05			0.05		
CD at 5%	0.14			0.14			0.14			0.14		
SE+(D)	0.03			0.03			0.03			0.03		
CD at 5%	0.09			0.09			0.09			0.09		
SE+(D X T)	0.08			0.08			0.08			0.08		
CD at 5 %	0.02			0.02			0.02			0.02		

Iron

In the present study, the iron content was significantly affected not only by the pre-treatment, drying methods, but also by the storage periods are presented in Table 5. The pre-treatment showed distinct effect on the retention of iron content, while pre-treatment of $MgCo_3$ and KMS have helped to maintain higher iron level than control. It was observed that significantly highest iron content was recorded in cabinet drying as compare to solar and sun dried sample. The better retention of iron content was observed significantly higher in treatment combination D_1T_6 (sun drying + $MgCo_3$-0.25%). Better retention of iron in sun dried sample compare to solar and cabinet drying. Similar results reported by Venkatesan and Arjunan (2014)

Table 5: Effect of storage period on Iron content of dried bitter gourd

Treatment	Iron mg/100g											
	Storage periods											
	0			30			60			90		
	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
T_1 (0.1% KMS)	6.48	4.71	5.48	6.45	4.68	5.45	6.41	4.64	5.41	6.36	4.59	5.36
T_2 (0.2% KMS)	6.54	4.78	5.56	6.51	4.75	5.53	6.47	4.71	5.49	6.42	4.66	5.44
T_3 (1.5% salt)	6.29	4.25	5.27	6.26	4.22	5.24	6.22	4.18	5.20	6.17	4.13	5.15
T_4 (2% salt)	6.32	4.32	5.33	6.29	4.29	5.30	6.25	4.25	5.26	6.20	4.20	5.21
T_5 (0.20%$MgCo_{3)}$	6.68	4.87	5.87	6.65	4.84	5.84	6.6	4.83	5.80	6.56	4.75	5.75
T_6 (0.25% $MgCo_3$)	6.71	4.90	5.91	6.68	4.87	5.88	6.64	4.80	5.84	6.59	4.78	5.79
T_7 (control)	6.13	4.14	5.18	6.10	4.11	5.15	6.06	4.07	5.11	6.01	4.02	5.06
SE(m)+(T)	0.002			0.002			0.002			0.002		
CD at 5%	0.008			0.008			0.008			0.008		
SE+(D)	0.001			0.001			0.001			0.001		
CD at 5%	0.005			0.005			0.005			0.005		
SE+(D X T)	0.005			0.005			0.005			0.005		
CD at 5 %	0.015			0.015			0.015			0.015		

Moisture %

It was observed from the data presented in Table 6 that moisture content in dried bitter gourd slices increased with advancement of storage upto 90 days. The gain of moisture was highest in control as compare to treatment combination D_2T_3 (blanching with salt 2% + cabinet drying). The progressive increase in moisture content was notified in all the samples dried by cabinet, solar and sun drying method. It is might be due to hygroscopic nature of the slices, which absorbed the moisture during storage. Cabinet drying recorded minimum moisture content as compare to solar and sun drying. Similar kinds of observation were also recorded by Singh *et al*., (2009) [8].

Table 6: Effect of storage period on moisture % of dried bitter gourd

Treatment	Moisture %											
	Storage periods											
	0			30			60			90		
	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
T_1 (0.1% KMS)	7.85	5.13	6.95	7.89	5.17	6.99	7.94	5.22	7.04	8.01	5.29	7.11
T_2 (0.2% KMS)	8.10	6.08	7.10	8.14	6.12	7.14	8.19	6.17	7.19	8.26	6.24	7.26
T_3 (1.5% salt)	7.10	5.08	6.30	7.14	5.12	6.34	7.19	5.17	6.39	7.26	5.24	6.46
T_4 (2% salt)	7.55	5.11	6.55	7.59	5.12	6.59	7.64	5.20	6.64	7.71	5.27	6.71
T_5 (0.20%$MgCo_{3)}$	8.35	6.25	7.35	8.39	6.29	7.39	8.44	6.34	7.44	8.51	6.41	7.51
T_6 (0.25% $MgCo_3$)	8.85	6.60	7.55	8.89	6.64	7.59	8.94	6.69	7.64	9.01	6.76	7.71
T_7 (control)	9.05	7.01	7.95	9.09	7.05	7.99	9.14	7.10	8.04	9.21	7.17	8.11
SE(m)+(T)	0.06			0.06			0.06			0.06		
CD at 5%	0.20			0.20			0.20			0.20		
SE+(D)	0.04			0.004			0.004			0.004		
CD at 5%	0.13			0.13			0.13			0.13		
SE+(D X T)	0.11			0.11			0.11			0.11		
CD at 5 %	0.34			0.34			0.34			0.34		

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