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The nutritional properties of dehydrated green *Momordica charantia* L. rings after various pre-treatments

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Abstract

Bitter gourd (*Momordica charantia* L.) is an important nutrient rich vegetable with plenty of health benefitting phytochemical properties, however the crop has a short shelf life. Dehydrating bitter gourd is a viable option to ensure availability in off-season but preserving the nutritive and medicinal value through the shelf life of dehydrated bitter gourd is a key challenge. The present investigative study was conducted to evaluate the effects of different pre-treatments on fresh green bitter gourd rings for preservation of important nutrient and phytochemical properties in the dehydrated product. The experiment was laid out in factorial completely randomized design with sixteen pre-treatments. Among these sixteen pre-treatments, T16 [salt blanching (SB) + potassium metabisulphite (KMS) + sodium carbonate (SC) + guargum (GG)] was the best performing treatment in terms of retention of important nutrient and phytochemical properties which included carotenoids (1.6 mg/100g), phenol (41.2 mg/g), ascorbic acid (78.8 mg/100g), fibre (2.4 %), antioxidant (42.3 %) and charantin (135.8 µg/g) of green bitter gourd rings after dehydration, followed by T15 [salt blanching (SB) + potassium metabisulphite (KMS) + guargum (GG)] treatment which retained maximum properties *viz.* fibre (2.2 %), antioxidant (40.9 %) and charantin (125.5 µg/g) after dehydration. The economic benefit of dehydrating green bitter gourd rings is also demonstrated by calculating the benefit cost ratio (BCR) which came out to be 1.75:1, making dehydration a preferred and sustainable option. Pre-treatments of green bitter gourd rings improved shelf life and nutritional quality of the product.

Key words: *Momordica charantia*, dehydration, charantin, carotenoids, ascorbic acid, antioxidant, phenol, fibre, benefit cost ratio

Introduction

Bitter gourd (*Momordica charantia* L.) is an important nutrient rich vegetable with plenty of medicinal properties. It is native to Asia with Eastern Asia and Southern China as its centres of domestication (Islam *et al.*, 2011). Popularly known as bitter melon, Karela or Balsam Pear (Satkar *et al.*, 2013), bitter gourd is an annual crop with all its parts like fruit, seeds, leaves, vines and roots being used as food and remedy for treatment of different ailments like diabetes mellitus, cough, respiratory diseases, skin diseases, wounds, etc (Islam *et al.*, 2011). Bitter gourd is considered to be a good source of vitamin C, vitamin A, carotenoids, antioxidant (Horax *et al.*, 2010), dietary fibre (Thakur and Sharma, 2016), etc. Apart from its nutritional benefits, bitter gourd is considered a stimulant, stomachic, laxative and blood purifier, good for obesity related complications (Alam *et al.*, 2015). It is known to be a super functional food with tremendous medicinal and it contains many health promoting phytochemicals (Tan *et al.*, 2016). The daily consumption of bitter gourd has increased many folds in the recent past due to its super therapeutic effects in the treatment of diabetes mellitus and leukemia (Bian *et al.*, 2016; Sorifa, 2018). The bitter gourd fruits are seasonal, highly perishable in nature. Freshly harvested bitter gourd fruits can be stored only for 4-6 days at ambient temperature moreover bitter gourd fruits are chilling sensitive and usually cannot be stored at a low temperature for a long period (Wang *et al.*, 2007). The post-harvest losses are reported to the tune of 25% in bitter gourd crop. The main reason for this loss is ripening and mechanical damage during transport. Therefore, bitter gourd should be processed to extend its shelf life while retaining its nutritional and medicinal properties. Furthermore, bitter gourd processing can provide a source of income for farmers and women, improving their living standard (Thakur & Sharma, 2016).

Because of its nutritional and medicinal properties, bitter gourd is in high demand all the year round. To achieve this objective, dehydration can serve as the most valuable and long-term method for storage. In the recent times with the use of mechanical driers for the dehydration of bitter gourd fruits, a good quality product can be obtained. It has been reported that pre-treatment of raw materials prior to drying improves the retention of nutrient components in various vegetables (Cakmak *et al*., 2016; Won *et al*., 2015; Liu *et al*., 2016). Apart from this, pre-treatments are found to improve the rehydration capacity and crispiness of the dried products (Rastogi, 2012; Doymaz and Ozdemir, 2014), along with help in creating a uniform microstructure of the tissues (Jiang *et al*., 2015). Deng *et al*. (2019) reviewed that pre-treatment is found to reduce the initial water content by modifying the properties of the tissues in such a way that results in increasing the drying rate, improving quality of the final dried product along with inhibiting the bio-enzymes, thereby minimizing possible deterioration reactions during dehydration and storage.

The current study investigates the effect of various pre-treatments on the nutrients and phytochemical properties of dehydrated green bitter gourd.

Material and methods

The laboratory experiment was conducted during 2016-2018 at Amity Institute of Horticulture Studies and Research, Amity University, Sector-125, Noida, Uttar Pradesh, India to study the effects of different pre-treatments on nutrient and phytochemical properties of dehydrated green *Momordica charantia* L. rings. The experiment was laid out in Factorial Completely Randomized Design with sixteen pre-treatments. In each treatment (T1-T16) 500 g of freshly cut bitter gourd rings were taken for experiment and each treatment was replicated thrice.

For blanching, the bitter gourd rings were dipped in boiling water and salt solution (2%) for 3 mins., respectively. Similarly, for chemical pre-treatments, the rings after blanching were soaked in different chemical solutions for 5 mins., *viz.*, T2 (WB + SS), T3 (WB + KMS, T4 (WB + SC), T5 (WB + GG), T6 (WB + SS + KMS), T7 (WB + SS + SC), T8 (WB + SS + GG), T9 (WB + KMS + SC), T10 (WB + KMS + GG), T11 (WB + SC + GG), T12 (SB + SC), T13 (SB + GG + SC), T14 (SB + KMS + SC), T15 (SB + KMS + GG) and T16 (SB + KMS + SC + GG), where WB – Water Blanching; SS – Salt Solution; KMS – Potassium metabisulphite; SC- Sodium carbonate; GG – Guargum; SB – Salt Blanching. The pretreated samples were shade dried and afterwards, the samples were dried in a laboratory mechanical dehydrator at 60 ± 2ºC till constant weight.

In the case of control sample T1 (WB), the bitter gourd rings were blanched in hot water for 3 minutes, without any pre-treatment solution, and then dried.

Data collection: The dehydrated green bitter gourd rings were subject to estimation of promising nutrient and phytochemical properties *viz.* ascorbic acid (mg/100g), total carotenoids (mg/100g), fibre test (%), charantin content (µg/g), total phenolic content (mg/g) and antioxidant activity (%).

Ascorbic acid: The ascorbic acid content of dried green bitter gourd rings was determined by 2,6-dichloroindophenol titration method as given in Association of Official Analytical Chemists (AOAC, 2005).

Total phenolic content: The total phenolic content of dried bitter gourd samples was determined using Folin-Ciocalteau (FC) assays Tan *et al*. (2008). The result was expressed as mg gallic acid equivalents (GAE)/100g of dried sample.

Antioxidant activity: The antioxidant activity of dried bitter gourd rings was estimated using DPPH (Diphenyl Picryl Hydroxyl) radical scavenging assay method of Tan *et al*. (2008). The antioxidant activity in percentage was expressed as:

Antioxidant activity (%) = [(blank A – Sample A)/ blank A] X 100

Total carotenoids: The estimation of total carotenoids content was carried out spectro-photometrically as per the method of Association of Vitamin Chemists and M. Freed (1966). Final content was calculated using standard carotene curve and expressed as mg per 100g of dried sample.

Fibre test: The fibre test was conducted to determine the percentage of crude fibre content in the dried green bitter gourd product as per the method described by Osborn and Voogt (1978) and AOAC (2005).

Charantin content: The charantin content in dehydrated green bitter gourd rings was determined using a C-18 Inertsil ODS-3 column (250 x 4.6 mm, 5 µm) and mobile phase composed of methanol: water (100:2, v/v). Flow rate of mobile phase was 1.0 mL/min and detection were carried out at 204 nm. Retention time of charantin was approximately 12.0 min. (Alam *et al*., 2009; Pitipanapong *et al*., 2007). The charantin content was expressed as µg/g.

Statistical analysis: In this experiment, Factorial Complete Randomized Design (CRD) with three replications was used for statistical analysis. All experiments were carried out in triplicate. All results were statistically analyzed using GS ANOVA (Windostat version 9.3) software. Fisher's Least Significance Difference (LSD) test at the significance level 5% ($P < 0.05$) was used to determine significant differences among samples.

Benefit cost ratio was calculated on the basis of total expenditure and returns details of green bitter gourd rings. Percent recovery of dried bitter gourd rings after dehydration process of fresh green bitter gourd rings was calculated.

Results and discussion

The data was recorded individually for different nutrients and phytochemical properties of dehydrated green *M. charantia* rings for the experiment conducted during 2016-2018. The data recorded was statistically analyzed and further interpreted as presented in Table 1.

Ascorbic acid (mg/100g): Among the different pre-treatments (Table 1), the ascorbic acid content was found to be highest in T16 (SB + KMS + SC + GG), while lowest ascorbic content was recorded in T6 (WB + SS + KMS). However, statistical analysis showed that all pre-treatments were significantly superior over control. The results obtained for ascorbic acid content was found to be comparable with the findings of Vega-Galvez *et al.* (2009), Chavan *et al.* (2010) and Kandasamy *et al.* (2014). Similarly, Biswas *et al.* (2018) reported significant variation among different treatments for ascorbic acid content after dehydration, thereby resulting in better retention of total ascorbic content in the dehydrated product. Waghmare *et al.* (2018) reported that ascorbic acid content was higher in the treated dehydrated bitter gourd rings due to protection of ascorbic acid by pre-treatment during dehydration process as sulphur dioxide inhibit the oxidative changes of ascorbic acid. Marul *et al.* (2007) also substantiated that the degradation of ascorbic acid content during drying process depends proportionately on the sample treatments before drying.

Total carotenoids (mg/100g): Among the different pre-treatments (Table 1), the statistical analysis revealed that T16 (SB + KMS + SC + GG) recorded highest content of total carotenoids, while the lowest total carotenoids content was recorded in T6

Table 1. Effects of pre-treatments on nutrient and phytochemical properties of dehydrated green *Momordica charantia* L. rings

Pre-treatments		Ascorbic acid (mg/100g)	Total carotenoids (mg/100g)	Antioxidant activity (%)	Fibre (%)	Charantin content (μg/g)	Total phenolic content (mg/g)
T1	Control	56.1i	0.75i	22.46i	1.79efgh	93.09i	34.09de
T2	WB + SS	68.4de	0.86f	23.52h	1.88defg	90.56jk	31.46g
T3	WB + KMS	51.96j	0.72j	22.23ij	1.76fgh	91.34j	30.58g
T4	WB + SC	62.2h	0.82g	24.77g	1.93de	95.72h	38.97b
T5	WB + GG	66.57f	0.79h	22.54i	1.78efgh	93.09i	40.72a
T6	WB + SS + KMS	42.36l	0.69k	20.75l	1.73h	89.19k	27.95i
T7	WB + SS + SC	44.44k	0.73ij	21.56jk	1.75gh	90.17jk	28.63hi
T8	WB + SS + GG	65.98f	0.93e	22.74i	1.9def	95.04h	35.46c
T9	WB + KMS + SC	70.83c	1.25b	30.73d	1.96d	103.72e	33.41ef
T10	WB + KMS + GG	68.91d	1.18c	27.03f	1.99cd	101.77f	34.39d
T11	WB + SC + GG	64.44g	0.82g	21.25kl	1.86defgh	96.11h	39.55b
T12	SB + SC	74.8b	0.93e	36.57c	2.2b	122.54c	29.32h
T13	SB + GG + SC	71.48c	1.03d	26.47f	2.13bc	110.06d	27.95i
T14	SB + KMS + SC	67.18ef	0.84g	27.85e	2.2b	98.55g	34.39d
T15	SB + KMS + GG	62.52h	0.79h	40.99b	2.22b	125.56b	32.53f
T16	SB + KMS + SC + GG	78.88a	1.63a	42.34a	2.42a	135.89a	41.21a

WB – Water Blanching; SS – Salt Solution; KMS – Potassium metabisulphite; SC- Sodium carbonate; GG – Guargum; SB – Salt Blanching)

(WB + SS +KMS). Our findings are in alignment with results reported by Dhotre *et al.* (2012) and Waghmare *et al.* (2018) who observed that higher total carotenoid content in the pretreated bitter gourd slices, which was mainly due to better protection of antioxidant by the preservative agent of KMS & salt, thereby reducing the discoloration of the dried bitter gourd. Similarly, Sra *et al.* (2011) reported results on dehydrated carrots, which are also in conformity with our findings. On the contrary, the study conducted by Selvakumar and Tiwari (2018) reported that the loss of carotenoid content in processed samples was due to leaching in syrup along with oxidation as well as thermal degradation processes.

Fibre Test (%): All the pretreatments were effective and statistically significant over control. Among the different pretreated samples (Table 1), the statistical analysis showed the highest fibre percentage in T16 (SB + KMS + SC + GG) and lowest fibre percentage was reported in pre-treatment T6 (WB + SS + KMS). The results indicated that the application of dehydration on pretreated samples had a significant effect on retention of high dietary fibre content of the final product as compared to control sample. Gupta *et al*. (2013) emphasized that the process followed for the dehydration of green leafy vegetables resulted in concentrating the nutrients present in them. Similar results were also reported by Borchani *et al*. (2012) working with dehydrated date fibre concentrate.

Charantin content (μg/g): Among the different pre-treatments (Table 1), the data reveals that T16 (SB + KMS + SC + GG) recorded highest charantin content, whereas T6 (WB + SS +KMS) recorded lowest charantin content. Thomas *et al.* (2012) expressed that all types of cooking methods result in small amount of change in the content of charantin in the bitter gourd fruit products.

Total phenolic content (mg/g): Among the different pretreated samples (Table 1), the data analysis showed highest total phenolic content (mg/g) in T5 (WB + GG) & T16 (SB + KMS + SC + GG). While, the lowest total phenolic content was observed in T13 (SB + GG + SC) & T6 (WB + SS + KMS). The differences between the treatments have been found to be significant. Waghmare *et al.* (2018) reported that the total phenol content was slightly higher in control samples in comparison of treated slices and it vary with KMS & salt concentrations. Further, they suggested that decrease in phenolic content in treated samples might be due to leaching of phenol content during soaking and blanching time in water. Similar results were exhibited by the studies conducted by Myojin *et al.* (2008) and Wen *et al.* (2010) reported that the total phenolic content of the oven dried bitter gourd rings was found to be higher in value due to increase in the total amount of simple phenols during oven drying process. Mrad *et al*. (2012) and Zahoor and Khan (2019) reported that cabinet drying leads to better retention of total phenolic content in the dried product as compared to conventional drying.

Antioxidant activity (%): Overall, the total antioxidant activity was slightly higher in treated samples as compared to the control. Among the different pretreated samples studied (Table 1), the data analysis showed highest and lowest antioxidant activity (%) by T16 (SB + KMS + SC + GG) and T6 (WB + SS + KMS), respectively. Waghmare *et al*. (2018) reported positive impact of pretreatment on antioxidant activity may be attributed to suppression of oxidation by antioxidants due to thermal inactivation of oxidative enzymes. It has also been reported that blanching cause disruption in the cell wall and cellular compartments, thereby resulting in release of the potent radical scavenging antioxidants. Zahoor and Khan (2019) suggested that more retention of antioxidant activity of bitter gourd rings is due to reduction of heat exposure during cabinet drying.

Benefit cost ratio: In the study, the benefit cost ratio (BCR) of 1.75: 1 and percent recovery of dried bitter gourd rings of about 55 kg for every 100 kg of fresh bitter gourd was observed (Table 2). Similar trends of results have been reported by other researchers. Subbaiah *et al.* (2018) in banana and Kanthakumari and Maheswari (2006) in grapes have also reported increased recovery of osmotically dehydrated product.

Salt blanching followed by pre-treatment [potassium metabisulphite (KMS) + sodium carbonate (SC) + guargum (GG)]

Table 2. Benefit cost ratio (BCR): Economics of production of dehydrated green *Momordica charantia* L. rings

S No.	Particular	Amount (Rs)
Expenditure details		
1.	Cost of 100 kg bitter gourd fruits @ Rs 10 per kg	1000.00
2.	Cost of salt (2 kg @ Rs 35 per kg)	70.00
3.	Cost of chemicals (KMS-250 g@ Rs 500 per kg, sodium carbonate – 1kg@Rs 140 per kg, guargum-1 kg @RS 150 per kg)	415.00
4.	Electricity charges (per unit@ Rs 8 for 40 hours	320.00
5.	Fuel charges (per commercial cylinder cost @ Rs1400)	500.00
6.	Cost of packaging and sealing (0.5 kg packs 100 packs, Rs 2 per pack	200.00
7.	Cost of labor @Rs 100 per day, 4 nos.	400.00
8.	Miscellaneous charges	100.00
	Total	3005.00
Return details		
1.	Recovery of dried bitter gourd rings	55.00 kg
2.	Gross Returns @ Rs 150/kg	8250.00
3.	Net Returns (8250-3005)	5245.00
4.	Benefit cost ratio (=Net Profits/Gross Cost)	1.75:1

and dehydration was found to be a suitable, economically viable and sustainable solution for enhancement of shelf life along with retention of nutrient and phytochemical properties of the green bitter gourd rings, thereby making availability of bitter gourd to the consumers feasible even during off-seasons.

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