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Research article

Dehydration for Better Quality Value Added Product of Bitter Gourd (*Momordica charantia* L.)

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ABSTRACT

An experiment was carried out to evaluate the dehydration and rehydration characteristics of bitter gourd (*Momordica charantia* L.) fruits. The slices of bitter gourd were blanched in boiling water and steam for 1, 2 and 3 minutes respectively. The slices were then dried at 65°C, 60°C and 55°C in a cabinet dryer up to constant moisture content.After final dehydration, rehydration for 10minutes, 20minutes, 30minutes, 50minutes, 70minutes and 90 minutes were undertaken respectively. There were seven treatments, replicated thrice and experiment was laid out in completely randomized design. The moisture content declined rapidly in bitter gourd rings dried at 65°C.The rehydration ratio recorded was 6.42, coefficient of rehydration was 13.91 and percent water in rehydrated sample was 88.14% respectively in water blanched samples. Hence, it is concluded that, among the three drying temperatures and two blanching methods, better dehydration and rehydration characters were reported in samples dried at 60°C and blanched in water for 2 minutes.

Introduction

Bitter gourd (*Momordica charantia* L.) is a member of the Cucurbitaceae family and known as Karela commonly in India. The important bitter gourd growing states are Maharashtra, Gujarat, Rajasthan, Punjab, Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, West Bengal, Orissa, Assam Uttar Pradesh and Bihar. The immature fruits are used in a wide variety of culinary preparations. It can be fried, deep-fried, boiled, pickled, juiced and dehydrated [1]. The fruits are antidotal, antipyretic tonic, appetizing, stomachic, antibilious and laxative. It has an action similar to insulin, thus helping in glucose metabolism. It purifies blood, activates spleen and liver and is highly beneficial in diabetes [2]. The fruit has great potential as a food source in both developing and industrialized countries. It is rich in iron, phosphorus and ascorbic acid which can supplement the requirement of nutritious food which is a prerequisite for a healthy life, not only for basic human survival, but also for safeguarding strong digestive, immune, cognitive, and other health functions. Thus, it can ensure food security which exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life.The preservation of vegetables can avert huge wastage as well as make them available in the lean season at remunerative prices. Among the different methods of preservation, dehydration is one of the best methods of preservation of fresh vegetables. When moisture is removed, they can be preserved over a long period with minimal microbial attack [3, 4]. Dehydration can reduce the bulk weight of vegetables, protect from browning and can be stored for long. In the process of dehydration, the moisture is removed by the application of artificial heat under controlled conditions of temperature, humidity and air flow. Blanching as a pretreatment to drying protects their colour, texture, and nutrients and inactivates harmful enzymes.The heat from blanching helps slow or stop the enzyme activity that can cause undesirable changes to reduce quality, which preservation methods such as drying cannot stop. Studies have shown that pre-treating vegetables by blanching in boiling water or steam intensifies the destruction of potentially harmful microorganisms on the surface of the vegetable

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during drying, including *Escherichia coli* O157:117, *Salmonella* species and *Listeria monocytogenes*. Blanching also relaxes tissues of produce thus reduces the drying time asthe cells in produce loose their wall integrity when blanched and thus bound water is lost faster during drying than when unblanched[5,6].There is a good prospect of dried bitter gourd for production of value added products. Through processing the market value of dehydrated product may be increased and production can be maximized. Thus, farmers would be benefited and encouraged to expand production. With keeping the above views in consideration, the investigation was conducted to study the dehydration and rehydration characteristics of bitter gourd.

Materials and Methods

The experiment was carried out in the laboratory conditions of the Department of Post Harvest Technology of Horticultural Crops, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India. Fresh fruits of bitter gourd cv. Meghna-2 were used for the present experiment.Firm, mature, uniform in colour and appearance fruits without any blemishes of medium size were selected for dehydration. The fruits were chopped from stem to blossom end using a stainless steel knife into uniform thickness of 0.6 cm. To obtain more uniform flesh, 2.0 cm of flesh at the stem end and blossom end were discarded. The cut pieces of bitter gourd were blanched in boiling water.Vapour blanching was done by using an autoclave at 121°C for 1, 2 and 3 minutes respectively. Blanched pieces were then dipped in a quick cooling solution of potassium metabisulphite 0.25% for 1 minute. After blanching the sample was uniformly spread on wire mesh to form a thin layer. This final sample contained 500 g of sliced bitter gourd. Bitter gourd slices were then dried at 65°C, 60°C and 55°C in a cabinet dryer up to constant moisture content. The dried samples were sealed properly in polyethylene bags. After final dehydration, rehydration with warm water (60-70°C) for 10, 20, 30, 50, 70 and 90 minutes were undertaken. The product was drained till dripping of water stops. There were seven treatments viz., T_1- Control, T_2- Water blanching for 1 minute, T_3- Water blanching for 2 minutes, T_4- Water blanching for 3 minutes, T_5- Vapour blanching for 1 minute, T_6- Vapour blanching for 2 minutes, T_7- Vapour blanching for 3 minutes. The analysis of data obtained in experiments was analyzed by Completely Randomized Design to test statistical significance at $p \leq 0.05$, with three replications, by adopting the standard statistical procedures [7]. The means between treatments were compared by Duncan's multiple range tests (DMRT)[8]. The moisture content of the dried samples were recorded during the entire period of drying followed by rehydration ratio, coefficient of rehydration and percent of water in rehydrated material.

Moisture content

The moisture content of dried slices was determined by drying until the weight of the dried sample become stable [9]. The moisture content of the dehydrated fruit was expressed as:

$$\text{Moisture content of dehydrated sample} = \frac{\text{Initial fruit weight} - \text{Final fruit weight}}{\text{Initial fruit weight}} \times 100\ (\%)$$

Rehydration ratio

The rehydration ratio was expressed as a ratio of water absorbed by the dried sample to the weight of the dried sample[10].

$$\text{Rehydration ratio} = \frac{\text{Wr}}{\text{Wd}}$$

where,

W_r = drained weight of the rehydrated sample

W_d = weight of the sample used for rehydration

Coefficient of rehydration

The coefficient of rehydration of the rehydrated samples was calculated by using the following formula [11].

Coefficient of rehydration =

$$\frac{\left(\begin{array}{c}\text{Drained weight of}\\ \text{dehydrated sample}\end{array}\right) \times (100 - \text{Moisture content of sample before drying})}{\left(\begin{array}{c}\text{Weight of dried sample taken}\\ \text{for rehydration} - \text{Amount of moisture present in}\\ \text{dried sample taken for rehydration}\end{array}\right) \times 100}$$

Percent water in rehydrated sample

The drained weight of the rehydrated sample being known, the per cent water content in the rehydrated material is given by [11].

$$\%\ \text{water in rehydrated sample} = \frac{(\text{Drained wt of rehydrated material}) - (\text{Dry matter content in sample taken for rehydration})}{\text{Drained wt of rehydrated material}} \times 100$$

Results

Moisture content: The data presented graphically in Figure-1, 2 and 3 revealed that the moisture content decreases continuously with enhancement of time. The moisture expulsion was found to be faster initially, up to 12 hours. Among various blanching treatments, the appearance of the slices was good in T_3 (water blanching for 2 minutes) compared to control. The average duration of drying was about 24 hours. The moisture content of bitter gourd slices when dried at 60°C, were brought down to 8.67 % (T_2- water blanching for 1 minute and T_3- water blanching for 2 minutes). The moisture exclusion was found to be faster initially, up to 16 hours. Among water and vapour blanching treatments, the appearance of the slices were at par with each other. The whole process of dehydration took approximately 28 hours for the moisture to become constant. On drying at 55°C, the moisture content of bitter gourd slices were reduced to 7.11 % in T_3 (water blanching for 2 minutes). The green colour of the bitter gourd slices became brownish due to degradation of chlorophyll pigments and the texture turns out to be very crispy in all the treatments including control. Among water and vapour blanching treatments, the appearance of the slices were at par with each other. The whole process of dehydration took approximately 28 hours for the moisture to become constant. Among the three drying temperatures, dehydration was faster when dried at 65°C compared to other two drying temperatures.

Figure-1 Influence of blanching methods on moisture content of bitter gourd fruits dried at 65°C

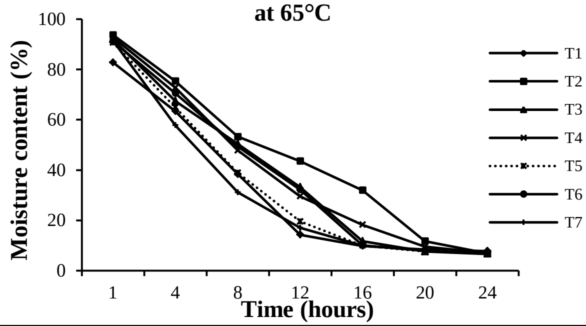


Figure-2 Influence of blanching methods on moisture content of bitter gourd fruits dried at 60°C

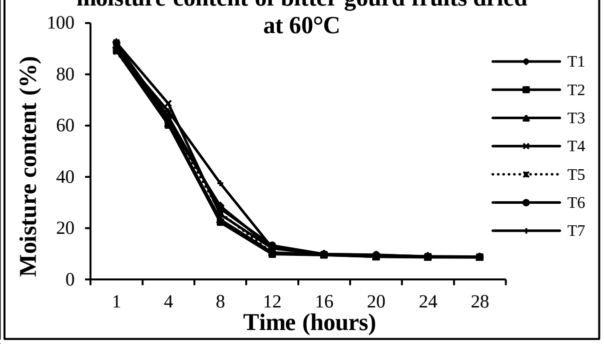
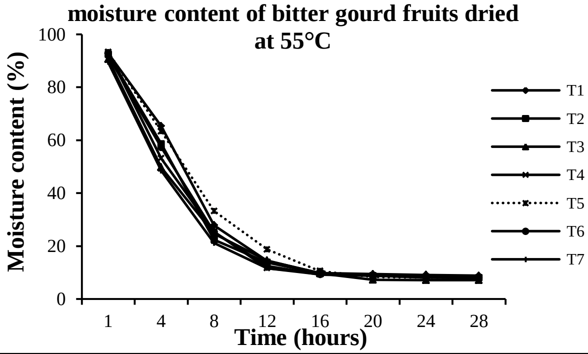


Figure-3 Influence of blanching methods on moisture content of bitter gourd fruits dried at 55°C



Rehydration ratio: The data illustrated that time, temperature and blanching methods effect have a reasonable impact on the rehydration ratio of the samples dried at 65°C, 60°C and 55°C respectively. The soaking in hot water showed that a maximum rehydration ratio (6.35) in water blanched (T_3-Water blanching for 2 minutes) bitter gourd slices dried at 65°C. The curves as graphically presented in Figure-4, 5 and 6 demonstrated the highest rehydration ratio 6.42 (T_3- Water blanching for 2 minutes) dried at 60°C after 90 minutes of soaking. Similarly, the rehydration ratio of the bitter gourd slices when dried at 55°C was recorded maximum (5.85) in T_3 (Water blanching for 2 minutes). Among the three drying temperatures and two blanching methods, the highest rehydration ratio was reported in water blanched (Water blanching for 2 minutes) samples and lowest in control dried at 60°C soaked in hot water for 90 minutes.

Figure-4 Influence of blanching methods on rehydration ratio of bitter gourd fruits dried at 65°C

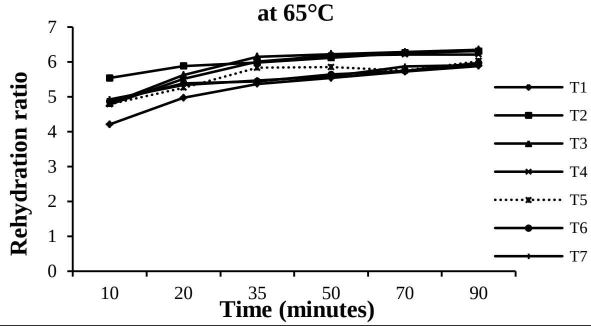


Figure-5 Influence of blanching methods on rehydration ratio of bitter gourd fruits dried at 60°C

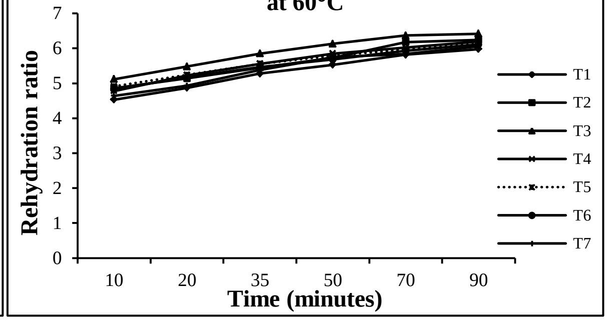
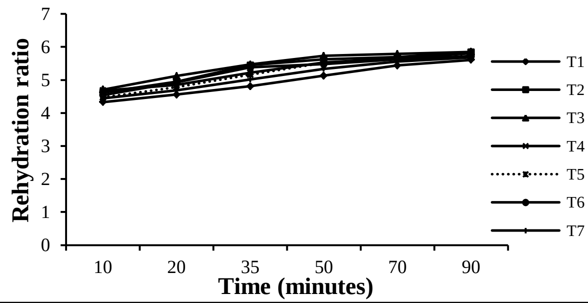


Figure-6 Influence of blanching methods on rehydration ratio of bitter gourd fruits dried at 55°C



Coefficient of rehydration: The coefficient of rehydration of bitter gourd slices dried at 65°C, 60°C and 55°C respectively are presented in Table-1. The coefficient of rehydration for the dehydrated bitter gourd slices when dried at 65°C was highest within the first 35 minutes during which majority of moisture absorption took place. Additional increases were recorded up to 90 minutes of soaking. The curves exhibit the characteristic moisture absorption patterns where initial high rate of water absorption is followed by slower absorption in later stages. The highest coefficient of rehydration (2.86) was found in T_3 (Water blanching for 2 minutes) and the lowest in control. Similarly, the coefficient of rehydration when dried at 60°C for bitter gourd slices was recorded highest within the first 35 minutes. Supplementary increases were documented up to 90 minutes of soaking. The highest coefficient of rehydration (13.91) was established in T_3 (Water blanching for 2 minutes) and the lowest in control (2.76) after 90 minutes of soaking. The coefficient of rehydration when soaked in hot water of bitter gourd dried at 55°C was noted highest during the initial phase which gradually slowed down in later stages. The maximum coefficient of rehydration (7.35) was found in T_3 (water blanching for 2 minutes) and the lowest in control (2.03). Among all the treatments, the highest coefficient of rehydration was reported in water blanched (Water blanching for 2 minutes) dried at 60°C.

Table 1: Influence of blanching methods on coefficient of rehydration of bitter gourd fruits at time interval dried at 65°C, 60°C and 55°C

Treatments	Coefficient of rehydration at 65°C					
	10 minutes	20 minutes	35 minutes	50 minutes	70 minutes	90 minutes
T_1	1.25 **a**	1.45 **a**	1.63 **a**	1.65 **a**	1.65 **a**	1.73 **a**
T_2	2.34 **g**	2.54 **f**	2.54 **e**	2.63 **e**	2.65 **e**	2.67 **e**
T_3	2.25 **f**	2.45 **e**	2.55 **e**	2.64 **e**	2.73 **f**	2.86 **f**
T_4	1.85 **e**	2.04 **d**	2.03 **d**	2.13 **d**	2.15 **d**	2.24 **d**
T_5	1.56 **c**	1.81 **c**	1.98 **c**	2.04 **c**	2.04 **c**	2.04 **c**
T_6	1.65 **d**	1.78 **c**	1.94 **bc**	1.95 **b**	1.97 **b**	1.97 **b**
T_7	1.45 **b**	1.73 **b**	1.92 **b**	1.94 **b**	1.94 **b**	1.96 **b**
C.D. (0.05)	0.048	0.040	0.041	0.045	0.049	0.036

SEm ±	0.016	0.013	0.014	0.015	0.016	0.012
Treatments	**Coefficient of rehydration at 60°C**					
	10 minutes	**20 minutes**	**35 minutes**	**50 minutes**	**70 minutes**	**90 minutes**
T_1	2.07 **a**	2.25 **a**	2.47 **a**	2.55 **a**	2.73 **a**	2.76 **a**
T_2	8.46 **f**	9.04 **f**	9.56 **f**	9.94 **f**	10.37 **f**	10.53 **f**
T_3	10.83 **g**	11.45 **g**	12.13 **g**	12.76 **g**	13.76 **g**	13.91 **g**
T_4	7.26 **e**	7.73 **e**	8.43 **e**	9.03 **e**	9.29 **e**	9.46 **e**
T_5	6.76 **d**	7.44 **d**	7.87 **d**	8.29 **d**	8.45 **d**	8.76 **d**
T_6	4.88 **c**	5.25 **c**	5.58 **c**	5.87 **c**	6.06 **c**	6.15 **c**
T_7	2.96 **b**	3.15 **b**	3.35 **b**	3.47 **b**	3.56 **b**	3.75 **b**
C.D. (0.05)	0.035	0.052	0.041	0.044	0.038	0.037
SEm ±	0.011	0.017	0.013	0.014	0.012	0.012
Treatments	**Coefficient of rehydration at 55°C**					
	10 minutes	**20 minutes**	**35 minutes**	**50 minutes**	**70 minutes**	**90 minutes**
T_1	1.53 **a**	1.63 **a**	1.73 **a**	1.85 **a**	1.94 **a**	2.03 **a**
T_2	4.14 **f**	4.46 **f**	4.75 **f**	5.03 **f**	5.05 **f**	5.06 **f**
T_3	5.83 **g**	6.34 **g**	6.95 **g**	7.14 **g**	7.33 **g**	7.35 **g**
T_4	3.34 **e**	3.53 **e**	3.93 **e**	4.05 **e**	4.04 **e**	4.13 **e**
T_5	2.87 **d**	3.04 **d**	3.24 **d**	3.43 **d**	3.53 **d**	3.65 **d**
T_6	2.32 **c**	2.43 **c**	2.64 **c**	2.83 **c**	2.93 **c**	2.94 **c**
T_7	1.84 **b**	1.94 **b**	2.03 **b**	2.16 **b**	2.25 **b**	2.34 **b**
C.D. (0.05)	0.041	0.039	0.043	0.043	0.041	0.039
SEm ±	0.013	0.013	0.014	0.014	0.013	0.013

(Means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)

(T_1- Control, T_2- Water blanching for 1 minute, T_3- Water blanching for 2 minutes, T_4- Water blanching for 3 minutes, T_5- Vapour blanching for 1 minute, T_6- Vapour blanching for 2 minutes, T_7- Vapour blanching for 3 minutes)

Percent water in rehydrated material: The drying procedure had a statistically significant influence on the percent water in rehydrated material in rehydration characteristic of the bitter gourd dried at 65°C, 60°C and 55°C. In Table-2, it is indicated that with the increase in soaking time the percent water increases gradually in the rehydrated samples. The percent water absorbed by the dried sample reached highest during the 35 minutes duration followed by gradual increase in the water content. The bitter gourd slices dried at 65°C, recorded highest water absorption (88.14%) in T_3 (water blanching for 2 minutes) up to 90 minutes of soaking followed by control the lowest (86.32%). The percent water in rehydrated bitter gourd when dried at 60°C, recorded the highest moisture content 86.24% (T_3- Water blanching for 2 minutes). The rehydration of the dehydrated bitter gourd dried at55°C indicated that the moisture content was 86.03 % after 90 minutes of soaking in T_3 (Water blanching for 3 minutes). Among the three drying temperatures and two blanching methods, the maximum reconstitution after rehydration of dried bitter gourd slices were reported in samples dried at 65°C and blanched in water for 2 minutes.

Table 2: Influence of blanching methods on percent water in rehydrated material of bitter gourd fruits at time interval dried at 65°C, 60°C and 55°C

Treatments	**Percent water in rehydrated material (%) at 65°C**					
	10 minutes	**20 minutes**	**35 minutes**	**50 minutes**	**70 minutes**	**90 minutes**
T_1	82.77 **b**	84.35 **a**	84.67 **a**	85.14 **a**	85.56 **a**	86.32 **a**
T_2	84.04 **d**	86.15 **e**	87.29 **f**	87.64 **e**	87.65 **f**	87.70 **f**
T_3	84.33 **e**	86.56 **g**	87.75 **g**	87.83 **f**	88.03 **g**	88.14 **g**
T_4	82.32 **a**	85.05 **b**	86.36 **c**	86.69 **c**	86.99 **d**	87.42 **e**
T_5	85.36 **f**	86.25 **f**	86.44 **d**	86.73 **c**	87.04 **e**	87.15 **d**
T_6	84.35 **e**	85.56 **d**	86.76 **e**	86.84 **d**	86.86 **c**	86.92 **c**
T_7	83.77 **c**	85.35 **c**	85.45 **b**	85.99 **b**	86.24 **b**	86.76 **b**
C.D. (0.05)	0.021	0.052	0.029	0.051	0.038	0.042
SEm ±	0.007	0.017	0.009	0.017	0.012	0.014
Treatments	**Percent water in rehydrated material (%) at 60°C**					
	10 minutes	**20 minutes**	**35 minutes**	**50 minutes**	**70 minutes**	**90 minutes**

T_1	79.74 **a**	80.89 **a**	82.53 **b**	83.65 **b**	84.14 **a**	84.49 **a**
T_2	82.15 **f**	83.26 **f**	84.25 **e**	84.85 **d**	85.25 **d**	85.95 **e**
T_3	81.84 **e**	83.13 **e**	84.44 **f**	85.14 **e**	85.94 **f**	86.24 **f**
T_4	82.35 **g**	83.46 **g**	84.54 **g**	85.24 **f**	85.80 **e**	85.93 **e**
T_5	80.43 **c**	82.14 **d**	83.23 **d**	84.05 **c**	84.35 **b**	84.95 **d**
T_6	80.33 **b**	81.35 **b**	82.44 **a**	83.32 **a**	84.55 **c**	84.65 **c**
T_7	80.75 **d**	81.96 **c**	83.03 **c**	83.64 **b**	84.34 **b**	84.55 **b**
C.D. (0.05)	0.061	0.056	0.056	0.035	0.052	0.052
SEm ±	0.020	0.018	0.018	0.011	0.017	0.017
Treatments	**Percent water in rehydrated material (%) at 55°C**					
	10 minutes	**20 minutes**	**35 minutes**	**50 minutes**	**70 minutes**	**90 minutes**
T_1	79.54 **a**	81.14 **a**	82.74 **a**	83.25 **a**	83.63 **a**	83.75 **a**
T_2	81.92 **f**	82.94 **f**	84.06 **g**	85.03 **g**	85.61 **f**	85.88 **f**
T_3	81.85 **e**	82.83 **e**	83.75 **d**	84.76 **e**	85.63 **f**	86.03 **g**
T_4	81.26 **c**	82.51 **d**	83.81 **e**	84.83 **f**	85.18 **e**	85.36 **e**
T_5	81.33 **d**	82.24 **b**	83.49 **b**	84.24 **b**	84.71 **d**	85.25 **d**
T_6	81.26 **c**	82.32 **c**	83.97 **f**	84.45 **d**	84.62 **c**	84.94 **c**
T_7	80.94 **b**	82.48 **d**	83.54 **c**	84.35 **c**	84.54 **b**	84.66 **b**
C.D. (0.05)	0.033	0.052	0.042	0.046	0.050	0.048
SEm ±	0.011	0.017	0.014	0.015	0.016	0.016

(Means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)

(T_1- Control, T_2- Water blanching for 1 minute, T_3- Water blanching for 2 minutes, T_4- Water blanching for 3 minutes, T_5- Vapour blanching for 1 minute, T_6- Vapour blanching for 2 minutes, T_7- Vapour blanching for 3 minutes)

Discussion

Dehydration is the process of removing water from a product under controlled conditions of air flow, temperature and humidity which reduces the moisture in the food to such a low level that inhibits the microbial growth leading to decay and spoilage[12].During drying the temperature increased to supply energy necessary to transfer water to vapour phase accelerates the reaction between different constituents in the product. The vegetable loses moisture thereby increasing the concentration of nutrients in the remaining mass. As the temperature of drying increased, removal of moisture from the plant material occurs at a faster rate, thus reducing time taken for drying. Since, drying takes place at faster rate at higher temperature probably the loss of volatile compounds and dry matter along with moisture will be reduced resulting in slightly better yield compared to low temperature drying which takes longer time [13].The drying time decrease with increase in temperature[14, 15]. Among the two blanching treatments, water blanching gave appreciable results than vapour blanching. This might be due to a more even heat penetration in water blanching than the steam blanching [16, 17]. Among the three drying temperatures and two blanching methods, the rehydration ratio, coefficient of rehydration and percent water in rehydrated material improved with decrease in temperature and reconstituted product was more appreciable in water blanching. The success of drying largely depends on the reconstitution properties of the dried products. Higher rehydration ratio indicates higher reconstitutability, which is a measure of recovery [18]. Dehydration increases the crystallization of polysaccharide gels by bridging reactive polymers groups closer together. In fresh vegetables, the free hydroxyl groups of polysaccharides have a secondary valence, which is almost completely fulfilled by water. These hydroxyl groups lose their non-covalently bound water due to dehydration. The shrinkage of the plant cells enables the adjacent polysaccharides molecules to be drawn together and thus fulfill the hydroxyl group's valence [19]. Drying results in toughened skins making it difficult for the water to penetrate into dried foods. Pretreatments for drying are usually designed to improve rehydration properties. Blanching pretreatment to drying causes loss in solids, enzyme denaturation, air removal from tissues, hydrolysis and solubilisation of structural polymers such as protopectin [20]. It will also cause starch granules to gelatinise, influencing the water binding capacity of the rehydrated product, as the gelatinised form would hold more water than the crystalline raw starch. Moreover, it expands intracellular air which flows through the intracellular lamella [21].

Conclusion

Bitter gourd is a highly nutrient packed fruit but during peak seasons due to lack of adequate processing facilities farmers are bound to sell their produce at low prices. So, the value addition of bitter gourd fruits by dehydration can be of high potential for both small farmers as well as for large scale industries which is relatively inexpensive, quick and easy in management. With respect to the results it can be concluded that, among the three drying temperatures and two blanching methods, higher dehydration and reconstitution characters were reported in samples dried at 60°C and blanched in water for 2 minutes. The rehydrated product could very well be utilized for substituting the fresh product in off-season.

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