Plant Archives Vol. 21, Supplement 1, 2021 pp. 1588-1594 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
doi link : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.S1.251

EFFECT OF PRETREATMENTS ON PHYSICAL ATTRIBUTES OF DEHYDRATED GREEN BITTER GOURD

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ABSTRACT

The present investigative study was conducted to assess the effect of different pretreatments individually and in combination on the physical quality attributes of pretreated and dehydrated green bitter gourd rings. The bitter gourd fruit being rich in medicinal properties especially for diabetic population is always in great demand throughout the year. Bitter gourd is a seasonal vegetable crop with poor shelf life and in order to make it available round the year, enhancing the shelf life of the produce is the need of the hour. Dehydration is the valuable method for storing this nutrient rich vegetable and with the help of mechanical driers for dehydration; a better quality product can be produced. The experiment was laid out in Factorial Completely Randomized Design with sixteen pre-treatments. With respect to the study conducted on the effect of pretreatments on the physical attributes of dehydrated green bitter gourd, it is pertinent to mention that the higher dehydration and physical attributes were reported in samples subjected to pretreatments as compared to the control. The higher retention of physical attributes like rehydration ratio and bulk density indicates that the pretreated samples before dehydration were found to have better reconstitution than the control sample. These findings indicate that in overall, the pretreated samples showed significant effects on retention of physical quality attributes of green bitter gourd rings after dehydration than the control sample. This may turn out to be a better option for substitution of fresh produce in off- season along with better transport and storage dynamics.
***Keywords*: Dehydration, Pretreatment, Bulk density, Rehydration ratio, Blemish count, Enzyme test**

Introduction

Bitter gourd (*Momordica charantia* L.) is a cucurbitaceae family vegetable, native to Asia (Yang and Walters, 1992). The unripe fruit is the edible part of this highly nutritive vegetable (Chandarshekhar *et al.*, 1989). Because of its high nutritive and medicinal value, bitter gourd is always in great demand especially for diabetic population round the year (Sandhya *et al.*, 2000; Harinantenaina *et al.*, 2006; Gopalan *et al.,* 2000). The unripe fruit of bitter gourd can be used to prepare many value added products like bitter gourd pickle, juice, dried rings, chips, etc. (Myjoin *et al.*, 2008). Bitter gourd crop being highly perishable in nature is reported to have post harvest losses at the tune of 25-30% during transportation and poor storage facilities. As a result, the degree of deterioration is high and results in limited availability of the produce in markets for consumption. In order to ensure the round the year availability of this wonder vegetable to the general public, dehydration method can be used along with preteatment and blanching for producing high quality product with good storage life (Snee *et al.*, 2011). As compared to other methods of preservation, a dried food product is reported to have a considerable good shelf life alongwith lower transportation, handling and storage cost (Mohamed *et al.*, 2017; Wakjira, 2010; Wang *et al.*, 2019). But it has been observed that drying generally results in altering the physicochemical properties and nutritive value of dried product despite improved shelf life. Thus, in order to address this problem, pretreatment followed by blanching is usually done before the fruits are subjected to drying so that the adverse changes which occur during drying and subsequently storage are reduced to great extent (Delfiya *et al.*, 2018; Adepoju & Osunde, 2017). Different pretreatment methods have been developed for fruit drying (Abano *et al.*, 2013; FAO, 1995; Karim *et al.*, 2008; Pott *et al.*, 2005).

Drying is believed to be one of the oldest methods of food preservation as it improves the shelf life of the food products by reducing the moisture content and microbial action (Khalloufi *et al.*, 2010; Madiouli *et al.*, 2012). Khalloufi *et al.* (2009) reported that food products went through various structural and morphological changes during drying process resulting in shrinkage of the food product. These changes were attributed to the removal of water, resulting in decrease in food volume.

According to McLaughlin and Magee (1998), the flow of heat and mass during dehydration process has a great impact on the physicochemical properties, chemical composition, mechanical properties, volume and porosity of the product obtained (Lewicki & Lukaszuk, 2000).Thereby modifying the quality of the dehydrated product on exposure. As stated by Rahman (2005), it is important to have an in-depth study of physicochemical properties of the food product as it plays an essential role while working on developing a good design of processing operations for better control and improvement in the quality of the product obtained.

Negi and Roy (2001) reported that the quality of a dehydrated product is not only affected by the type of drying conditions but also on other processes carried out before and after the drying process. Severini *et al.* (2005) stated that blanching results in overall improvement in the quality of the final product after dehydration as blanching increases the cell membrane permeability, which in turn have a positive impact on the rate of moisture removal. The common blanching methods like hot water blanching or steam blanching results in increased dehydration rates as it causes alteration in the physical properties of the final dried product, thereby improving its quality attributes (Alzamora *et al.*, 2000; Rocha *et al.*, 1993). Sablani *et al.* (2011) and Ramesh *et al.* (2001) suggested that the effective diffusivity of moisture increased due to higher cell wall destruction, resulting in less resistance to moisture movement during dehydration after blanching. The samples subjected to blanching before dehydration have shown better retention of vitamins due to low oxygen atmosphere, faster drying rate and high color value in the final product (Rocha *et al.*, 1993; Singh *et al.*, 1996; Ramesh *et al.,* 2001; Hossain *et al.,* 2007).

Sagar (2001) and Kumar *et al.* (1991) reported that bitter gourd tends to develop rubbery texture and subsequently becomes brown alongwith losing its properties of bitterness, cholorophyll and ascorbic acid content during drying. The hygroscopic nature of the dehydrated products results in exchange of moisture between the dried food product and its surrounding atmosphere. However, these changes can be mitigated by use of adequate packaging material for storing a dried food product.

Thus, in the present study, the effect of various pretreatments on drying characteristics and physical quality attributes of dehydrated green bitter gourd is mainly focused as it plays a promising role in addressing the issues of food security and nutrition concerns around the world. The green bitter gourd rings were blanched by dipping dipped in boiling water and salt solution (2%) for 3 mins, respectively, followed by pretreatment in different solutions include salt, chemical viz. sodium carbonate and potassium meta bisulphite; and starch (guargum) and then subjected to dehydration in cabinet drier.

Material and Methods

The laboratory experiment was conducted during 2016-2017 and 2017-2018 at Amity Institute of Horticulture Studies and Research, Noida to study the effects of various pretreatments on drying characteristics and physical quality attributes of dehydrated green bitter gourd. 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.

Hot water blanching: For carrying out the blanching in hot water, the bitter gourd rings were dipped in hot water bath at 90C in order to ensure full coverage of the rings by water for 3 mins (Doymaz, 2010; Galoburda *et al.*, 2012; H. Wang *et al.*, 2018).

Salt Solution blanching: The salt solution blanching was carried out by dipping the bitter gourd rings in hot water containing 2% salt solution for 3 mins in the container in order to ensure full coverage of the rings (Abano and SamAmoah, 2011; Abano *et al.*, 2013).

Pretreatment Solution: The bitter gourd rings after blanching were soaked in different pretreatment solutions viz. Salt (2%), KMS (0.2%), Sodium carbonate (1%), Guar gum (1%) and their different combinations for 5 mins., respectively. The pretreated samples were removed from the solution and evenly spread over a perforated tray so as to allow the excess solution to drip off and let the samples shade dried (Nyangena *et al.*, 2019, Wiriya *et al.*, 2009; Tunde-Akintude, 2010). Thereafter, the samples were subjected to drying in a laboratory mechanical dehydrator at 60± 2ºC till constant weight.

Control sample: In case of control sample, the bitter gourd rings were only blanched in hot water for 3 mins., and were not subjected to any pretreatment solution and subsequently subjected to drying.

Data collection: The dehydrated green bitter gourd rings were subject to estimation of drying characteristics and physical attributes viz. moisture content (%), bulk density, rehydration ratio, blemish count and enzyme test activity. These estimations were carried out as per the methods of Ranganna (2014) and Association of Official Analytical Chemists (AOAC) (2005), immediately after preparation of dried bitter gourd rings.

Moisture Percentage: The moisture content percentage of dried green bitter gourd rings slices was determined by drying until the weight of the dried sample become stable (AOAC, 2005). The moisture content of the dehydrated fruit was expressed as:

$$\text{Moisture content of dehydrated sample} = \frac{[\text{Initial Sample Weight - Final Sample Weight}]}{\text{Initial Sample Weight}} \text{X } 100\,(\%)$$

Rehydration Ratio: The rehydration ratio was expressed as a ratio of weight of the rehydrated sample to the weight of the dehydrated sample (Ozgur *et al.*, 2011; Ranganna, 2014).

$$\text{Rehydration ratio} = \frac{\text{Weight of the rehydrated sample}}{\text{Weight of the dehydrated sample}}$$

Bulk Density (g/cm^3): Bulk Density calculation: Bulk density indicates the weight of substance held in a unit volume and is of particular importance in the packaging of the product. According to Ranganna (2014) for its determination, note the tare weight of a glass cylinder of exactly 625 ml water capacity and then fill the sample with the help of a hopper which is suspended at a height of 3 cm. The excess of sample above the rim of the cylinder was striked off and again the weight noted.

$$\text{Bulk density (lb/cuft} = \frac{\text{Wt of sample}}{10}$$

The compacted bulk density can be calculated by weighing after the cylinder has been repeatedly tapped and refilled.

Blemish count: Commercially, a limited number of blemishes are permitted in dehydrated vegetables but the tolerance limit is controlled rigorously. It is important that blemish should not be present in a dehydrated product but minor or slight blemishes in dry state which usually disappears on reconstitution are generally (Greensmith, 1998). According to Ranganna (2014), for calculation of blemish count, firstly we rehydrated 50 g representative sample of the dehydrated material, followed by visual counting of the number of surface blemishes. The number of blemishes counted thus, were multiplied by 2 and reported as number of blemishes per 100 g of sample.

Enzyme Test (unit/min):

1. **Enzyme Test (unit/min) CatAct O.D. at 240 nm:** For calculating catalase enzyme reaction, take a test tube of approximately 1 inch in diameter and 6 inch deep and fill this test tube upto a depth of 1 inch (approximately) with small pieces of the dehydrated vegetable material. This was then covered with water and allowed to stand for 10 mins., followed by adding an equal volume of 3% hydrogen peroxide and by gentle shaking, the contents of the tube were mixed. If there is evolution of oxygen, then the test is considered positive for the presence of catalase enzyme (Ranganna, 2014).
2. **Enzyme Test (unit/min) Perox Act O.D. at 470 nm:** For calculating peroxidase enzyme reaction, take a small portion of the sample and reconstitute in cold water for 10-15 min. Pour of excess water. Add small pieces of the reconstituted sample to a depth of about 1 inch in a test tube 1 inch in diameter. Add 10 ml of water and 1 ml of a 1% guaiacol solution in 95% alcohol and 1 ml of a fresh 0.5% hydrogen peroxide solution [10 ml of (3%) hydrogen peroxide added to 50 ml water]. Then the test tube is shaked to mix the contents and reaction was noted after 5 and 10 mins. The presence of a pronounced reddish brown colouration throughout the tissue which is not restricted to the veins, indicated a positive test for peroxidase enzyme reaction (Ranganna, 2014).

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.

Results and Discussion

The physical attributes of dehydrated green bitter gourd samples were determined and the results were presented in Table 2.

Moisture percentage

The dehydration process carried out produced dried bitter gourd rings with moisture content ranging between 23.417 to 8.842 %. The lowest moisture content percentage of 8.842 reported in the final dried bitter gourd rings product is optimum to reduce the mould growth, yeast and bacterial infections during subsequent storage (Nyangena *et al.*, 2019). Further, the low moisture content in the dried product not only reduces the perishability of the dried bitter gourd rings but also improves the overall shelf life of the product (Agoreyo *et al.*, 2011). Among the different pretreatments (Table 1 and Figure 1), the pooled data for first year and second year showed that moisture content percentage was found to be lowest in T11 and T15, followed by T14 and T1. The highest moisture content percentage was observed in T8, followed by T7 which is at par with T6 and followed by T3. The general mean for moisture percentage is 11.131 % and CV is 2.764. Statistical analysis reveals that there was significant impact of pretreatments on the moisture percentage. Tolera and Abera (2017) explained that such response is attributed to the osmotic pressure in the osmotic solution forcing the moisture of the internal tissues to come out even before drying. Moreover, studies conducted by Raja *et al.* (2017) and Sengkhamparn *et al.* (2013) revealed that the process of blanching results in softening of the texture of the material, which further makes the removal of water easier. The results showed that there was significant difference between samples subjected to hot water blanching and salt blanching along with different pretreatments. The pretreatments caused significant ($P<0.05$) differences on moisture percentage in dehydrated samples as depicted in Table 2. The effect of pretreatments on the final moisture percentage in the dehydrated green bitter gourd rings is evident from the range of moisture percentage in the final dried product between 23.417 to 8.842 %. Similar results were reported by Abano *et al.* (2013) and Adepoju & Osunde (2015) in mango, Mohseni and Ghavidel (2011) in tomato, Abano and Sam (2011) & Adepoju & Osunde (2015) in banana and Raja *et al* (2017) in papaya leaf powder. Bhattacharjee *et al.* (2016) reported that 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.

Bulk density (g/cm^3)

The variation in the values of the bulk density among different pretreated samples after dehydration process was observed. In general during dehydration, bulk density increased initially, reached a peak and thereafter decreased at the end of the drying process (Mayor *et al.*, 2011). The study of bulk density of the dried product is considered as an important physical parameter for packaging and storage purpose (Rahman, 2005). Basically, the transfer of mass and heat in solids depends on bulk density values of the product along with the sensory and textural properties of the dried product (Rahman, 2001). Low value of bulk density leads to poor rehydration capability as reported by McMinn and Magee (1997). The changes in the bulk density value for different vegetable and fruit dried products as reported by Lozano *et al.* (1983) and Krokida and Maroulis (1997). Rahman (2001) observed in some fruits and vegetables, that bulk density increases during dehydration e.g. carrot and banana, while in others it decreases as observed in garlic and sweet potato. Such a different behavior may be associated with the initial structural and chemical composition or presence of the soft/rigid structures on the fresh raw material which can lead to different stress behavior during processing. The bulk density of the dried green bitter gourd rings varied between the range of 0.605 g/cm^3 to 0.147 g/cm^3. Among the different pretreatments (Table 1 and Figure 2), the pooled data for first year and second year showed that bulk density of different pretreated samples was found to be highest in T10, followed by T9 & T11 which is at par with T4. The lowest bulk density was observed in T8, followed by T13. The general mean for bulk density is 0.452 g/^{cm3} and CV is 4.789. The significant differences were observed among the samples for bulk density on statistical analysis which may be attributed to the subjecting of samples to different pretreatments before dehydration.

Rehydration ratio:

The data reveals that the pretreatments had a significant impact on the rehydration ratio of the green bitter gourd rings dried at 60 degree C. The success of drying largely depends on the reconstitution properties of the dried products. Higher rehydration ratio indicates higher re-constitutability, which is a measure of recovery (Manjula *et al.*, 2009). The pretreatments caused significant ($P<0.05$) differences among samples during dehydration as shown in Table 1 and Figure 3. The influence of pretreatments on the dried green bitter gourd rings is evident from the variation of rehydration ratio value from 10.793 to 8.132. The highest rehydration ratio was observed in T7, followed by T14, T4, T8 and T11. The lowest rehydration ratio was reported in the T12, T13 and T2, followed by T16, T6 and T3. The general mean for bulk density is 9.026 and CV is 4.265. 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 (Kuprianoff, 1958). 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 (Mate *et al.*, 1998). It will also cause starch granules to gelatinise, influencing the water binding capacity of the rehydrated product, as the gelatinized form would hold more water than the crystalline raw starch. Moreover, it expands intracellular air which flows through the intracellular lamella (Alam *et al.*, 2014).

Blemish count :

Among the different pretreated samples (Table 1 and Fig. 4), the pooled data analysis showed highest blemish count in T16 & T10 which is at par with T5, T8, T11, T14 & T15. The lowest blemish count was reported in pre-treatment T1, T2, T3, T4, T6, T7, T9 and T12. The general mean for blemish count is 2.708 and CV is 26.492. From the data obtained, it is clear that most of the samples had shown a limited number of minor blemishes, which is permitted in dehydrated vegetables on a commercial level (Greensmith, 1998). Although presence of blemish on a dehydrated product is an undesirable attribute but a tolerated limit of slight blemish in dry product, which may disappears on reconstitution (Greensmith, 1998).

Enzyme test :

a) **Enzyme Test (unit/min) CatAct O.D. at 240 nm:** Among the different pretreated samples (Table 1 and Fig. 5a), the pooled data analysis showed highest enzyme CatAct (unit/min) O.D. at 240 nm in pretreated sample T11 followed by T14 and T10. The lowest enzyme CatAct (unit/min) O.D. at 240 nm was observed in T2 followed by T6 & T13. The general mean for enzyme CatAct (unit/min) O.D. at 240 nm is 4.730 and CV is 3.754. Falk *et al* (1919) reported that the heat and time are the most limiting factors for bringing about any change in the enzyme actions as it appears that the shorter time in which heat is applied, the smaller will be the changes in the enzyme properties during dehydration by the oxygen of the air.

b) **Enzyme Test (unit/min) PeroxAct O.D. at 470 nm:** Among the different pretreated samples (Table 1 and Fig. 5b), the pooled data analysis showed highest enzyme PeroxAct (unit/min) O.D. at 470 nm in pretreatment T11, followed by T14 and T10. The lowest enzyme PeroxAct (unit/min) O.D. at 470 nm was observed in T13 followed by T3. The general mean for enzyme PeroxAct (unit/min) O.D. at 470 nm is 47.452 and CV is 1.389. The fact that enzyme peroxidase has thermal resistance, so it's not inactivated completely but its activity decreases as a result of blanching and pretreatment processes. The data Table 2 shows that enzyme peroxidase activity in dehydrated green bitter gourd samples was reduced significantly as compared to fresh bitter gourd samples. The blanched and pretreated green bitter gourd samples were dried in a laboratory mechanical dehydrator at 60± 2ºC till constant weight is achieved. Castro *et al* (2008) reported that at 60°C temperature, the peroxidase activity remains unaffected with 95% retention, whereas at 70°C peroxidase activity decreases 40% versus the conventional 60°C drying process. This leads to comparatively higher product stability, however, at 80°C peroxidase enzyme tends to attain 26% reactivation as compared to 70°C drying process. So, this means peroxidase enzyme is more likely to be reactivated at higher temperature range as reported by Martin (2004). Therefore according to Castro *et al*. (2008) peroxidase activity is reduced by 24.97 % at 70°C in 20X20 lab tempering drying than the conventional drying method with peroxidase activity of 39.7% for obtaining a better quality carrot dehydrated product with substantial energy saving as well. Falk *et al.* (1919) reported that the heat and time are the most limiting factors for bringing about any change in the enzyme actions as it appears that the shorter time in which heat is applied, the smaller will be the changes in the enzyme properties during dehydration by the oxygen of the air.

Conclusion

Bitter gourd is a super vegetable in terms of its high nutrient content but it is being sold at low market value during peak season of harvesting due to lack of transport and processing facilities status in a developing country like India. Thus, in order to mitigate this challenge in production chain of bitter gourd crop, value addition of bitter gourd fruits by dehydration will be an easy & inexpensive way for increasing the potential availability of this vegetable crop. Moreover, with respect to the study conducted on the effect of pretreatments on the physical attributes of dehydrated green bitter gourd, it is pertinent to mention that the higher retention of desirable physical attributes were reported in samples subjected to pretreatments as compared to the control. The higher retention of physical attributes like rehydration ratio and bulk density indicates that the pretreated samples before dehydration were found to have better reconstitution than the control sample These findings indicates that in overall, the pretreated samples showed significant effects on retention of physical quality attributes of green bitter gourd rings after dehydration than the control sample. This may turn out to be a better option for substitution of fresh produce in off- season along with better transport and storage dynamics.

Table 1: Effect of pretreatments on medicinal attributes of dehydrated green bitter gourd rings {Pooled data of year 1 (2016-2017) and year 2 (2017-2018)}

S No.	Pretreatments	Bulk Density (g/cm3)			Moisture content (%)			Enzyme Test (unit/min) CatAct O.D. at 240 nm			Enzyme Test (unit/min) PeroxAct O.D. at 470 nm			Rehydration Ratio			Blemish Count		
		Pooled	± SD		Pooled	± SD		Pooled	± SD		Pooled	± SD		Pooled	± SD		Pooled	± SD	
T1	Control	0.465	0.024	def	9.310	0.316	g	3.862	0.170	ij	41.907	1.254	g	8.727	0.392	d	2.000	0.000	c
T2	Water Blanch+Salt Dip 2%	0.458	0.020	ef	11.260	0.362	cd	**3.783**	**0.169**	j	39.957	1.203	i	8.132	0.382	e	2.000	0.000	c
T3	Water Blanch+KMS 0.2%	0.475	0.024	de	11.367	0.363	c	3.910	0.170	hij	**38.982**	**1.177**	j	8.425	0.385	de	2.000	0.000	c
T4	Water Blanch+Sodium Carbonate 1%	0.555	0.024	b	10.580	0.343	e	4.125	0.173	g	44.832	1.331	e	10.325	0.421	b	2.000	0.000	c
T5	Water Blanch+GuarGum 1%	0.485	0.024	cd	9.700	0.325	f	5.450	0.201	d	54.582	1.593	c	8.853	0.394	d	3.333	1.033	ab
T6	Water Blanch+Salt Dip+KMS	0.447	0.022	f	12.040	0.382	b	**3.822**	**0.170**	j	40.932	1.228	h	8.532	0.389	de	2.000	0.000	c
T7	Water Blanch+Salt Dip+SodCarb	0.448	0.020	f	11.845	0.377	b	4.085	0.173	gh	43.857	1.305	f	**10.793**	**0.431**	a	2.000	0.000	c
T8	Water Blanch+Salt Dip + GuarGum	0.107	0.005	h	23.417	0.693	a	4.495	0.181	f	51.657	1.514	d	9.380	0.402	c	3.333	1.033	ab
T9	Water Blanch+KMS+SodCarb	0.575	0.024	b	9.895	0.329	f	4.065	0.173	ghi	56.532	1.645	b	8.853	0.394	d	2.000	0.000	c
T10	Water Blanch+KMS+GuarGum	**0.605**	**0.024**	a	11.065	0.358	cd	6.708	0.230	c	56.532	1.645	b	8.765	0.392	d	4.000	0.000	a
T11	Water Blanch + SodCarb + Guargum	0.575	0.024	b	**8.792**	**0.331**	h	7.380	0.245	a	58.482	1.698	a	9.643	0.409	c	3.333	1.033	ab
T12	Salt Blanch+SodCarb	0.458	0.020	ef	9.800	0.325	f	4.085	0.173	gh	39.957	1.203	i	8.230	0.381	e	2.000	0.000	c
T13	Salt Blanch+Guargum+Sodcarb	0.147	0.005	g	10.970	0.353	d	**3.755**	**0.166**	j	**38.982**	**1.177**	j	8.142	0.382	e	2.667	1.033	bc
T14	Salt Blanch+KMS+Sodcarb	0.470	0.027	def	9.215	0.311	g	6.933	0.234	b	56.532	1.645	b	10.325	0.421	b	3.333	1.033	ab
T15	Salt Blanch+KMS+Guargum	0.465	0.024	def	**8.842**	**0.303**	h	4.163	0.176	g	43.857	1.305	f	8.795	0.392	d	3.333	1.033	ab
T16	Salt Blanch + KMS + Sodcarb + Guargum	0.505	0.024	c	9.995	0.329	f	5.060	0.193	e	51.657	1.514	d	8.492	0.389	de	4.000	0.000	a
	Gen. Mean	**0.452**	***		**11.131**	***		**4.730**	***		**47.452**	***		**9.026**	***		**2.708**	***	
	C.V.	4.789			2.764			3.754			1.389			4.265			26.492		
	F Prob.	0.000			0.000			0.000			0.000			0.000			0.000		
	S.E.M.	0.009			0.126			0.072			0.269			0.157			0.293		
	C.D. 5%	0.025			0.355			0.205			0.761			0.444			0.828		
	C.D. 1%	0.033			0.472			0.272			1.011			0.591			1.101		

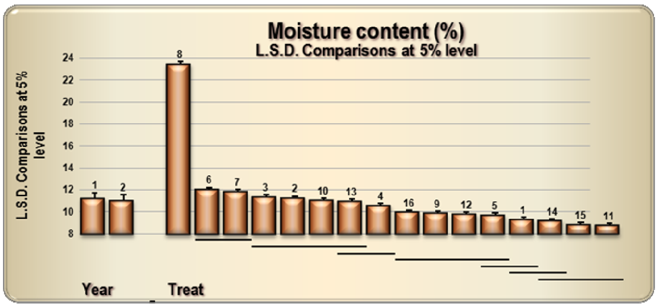

Fig. 1: Effect of different pretreatments on moisture content (%) of dehydrated green bitter gourd rings

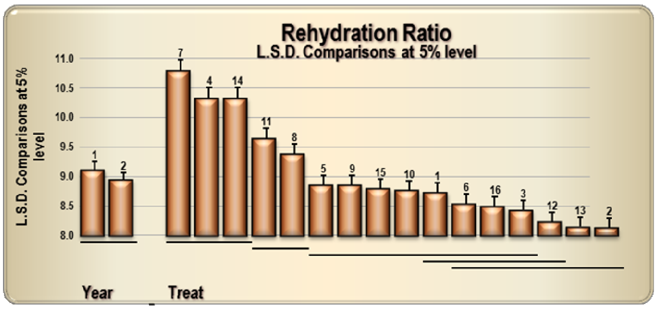

Fig. 3: Effect of different pretreatments on rehydration ratio of dehydrated green bitter gourd rings

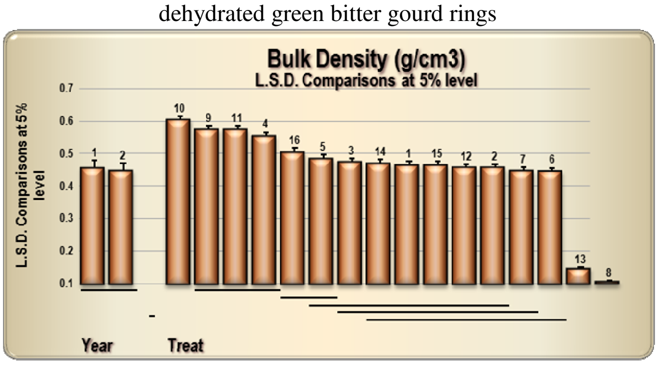

Fig. 2: Effect of different pretreatments on bulk density (g/cm3) of dehydrated green bitter gourd rings

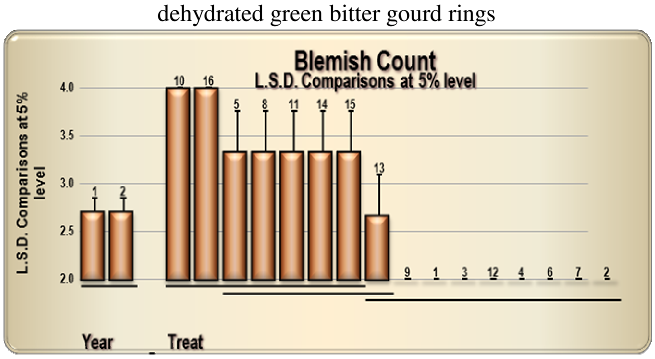

Fig. 4: Effect of different pretreatments on blemish count of dehydrated green bitter gourd rings

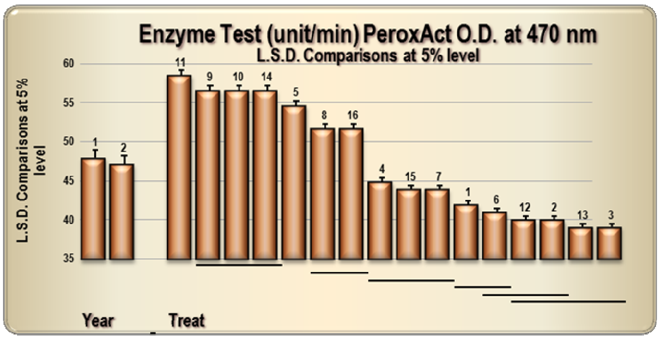

Fig. 5(a): Effect of different pretreatments on enzyme test (unit/min) PeroxAct O.D. at 470nm of dehydrated green bitter gourd rings

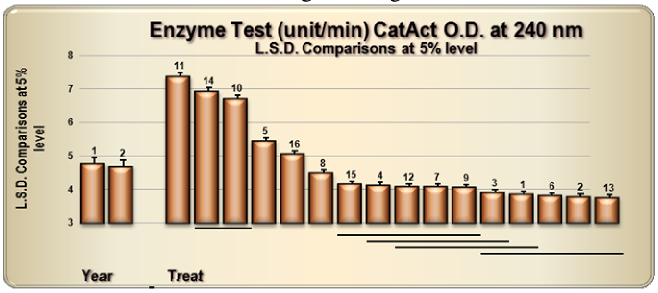

Fig. 5(b): Effect of different pretreatments on enzyme test (unit/min) CatAct O.D. at 240nm blemish count of dehydrated green bitter gourd rings

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