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Effect of pre-treatments and storage on quality of green chilli powder

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Abstract

India is one of the largest producers of commercial vegetables and spices, including chilli (*Capsicum annuum* L.). To reduce postharvest losses and enhance value addition, green chilli preparation and preservation are important. The aim of the present study is to investigate the effect of different chemical pre-treatments on green chilli powder quality as well as the effect of storage on its quality. The experiment was laid out in the Factorial Completely Randomized Design (FCRD) with eight different pre-treatments and three storage intervals. The significantly lowest L*, a* and b* colour values and the significantly maximum solubility, total ash, crude fiber, acidity, ascorbic acid, total phenol and capsaicin were observed during 180-day storage period in the pre-treatment of green chilli with 1% ascorbic acid by dipping for 10 minutes. During the 180-day storage period, the Total Plate Count was increased but remained within permissible limit. The maximum protein content was observed in pre-treatment with 0.3% sodium metabisulphite, while the lowest Total Plate Count was recorded in pre-treatment with 0.5% chitosan. Based on the study of various parameters, dipping green chilli in 1% ascorbic acid for 10 minutes followed by tray drying produced superior quality. The green chilli powder was stored for a duration of 180 days under ambient conditions.

Keywords

green chilli powder; pre-drying treatment; processing; shelf life; storage study; tray drying

Introduction

India is a significant producer of commercial vegetables and spices, including chilli (*Capsicum annuum* L.). Chillies are native to South America and the Portuguese introduced them to India in the middle of the seventeenth century. *Capsicum annuum* and *Capsicum frutescens* are the two major cultivated varieties. All *Capsicum* spp. belongs to the Solanaceae family. (2). The genus *Capsicum* has more than 30 species, five of which have been grown under cultivation: *Capsicum annuum, C. chinense, C. pubescens, C. frutescens* and *C. baccatum* (1). The chilli fruits contain 65 to 75% of moisture during harvesting. The moisture content needs to be reduced to 8-10% to make the dried chilli powder (3). Green chilli is more commonly used than red chilli. Green chilli prices are usually higher during the growing season because production is naturally low at this time of year. Due to high moisture content, green chillies are perishable having limited shelf life, it deteriorates quickly during marketing, transportation and storage. Lack of processing and storage methods has resulted in a significant amount of green chilli being wasted in the field (4). In terms of medicine, green chili is widely used as

an anti-inflammatory, anti-epileptic, anti-cancer, anti-ulcer, analgesic and antihemorrhoidal agent. It is used to treat psoriasis, severe migraines and burns. It also helps with diabetes and cardiac problems (5). Microbial, enzymatic and chemical reactions, discoloration and textural changes are factors that lower green chilli powder quality and thus affect consumer acceptance. In order to extend its shelf life, chilli needs to be dried.

Green chilli must be pre-treated before drying to improve the quality requirements of the finished product. Reducing enzymatic activity, increasing flavour and colour, minimising nutrient loss, reducing microbial decomposition and maintaining even drying are the primary goals of treating fruit prior to drying (6). Green chilli is wasted on farms during the peak harvest season due to a lack of suitable processing and preservation technology. Processing and preserving green chilies is crucial to lowering postharvest losses, enhancing value addition and boosting the nation's economy. By offering ready-to-use green chili powder and paste, kitchen preparation time can be saved. It might also pave the way for industrialization, export revenue and employment opportunities. Sadly, there has been relatively little research on green chilli drying, processing and preservation. In fact, processing green chilli powder is still an emerging technology (3).Due to high demand and value of the green chilli powder, this experiment attempts to standardize the process technology for its quality production. The current experiment aims to standardize the process technology for the production of high-quality green chilli powder, considering its future demand and value. Green chilli powder is a valuable addition to modern life due to its convenience, health benefits and culinary adaptability. Employing effective pre-treatments ensures high-quality powder with preserved nutritional and sensory attributes, meeting the demands of health-conscious consumers and the food industry.

Materials and Methods

The experiment was carried out at the Department of Post Harvest Management of Medicinal, Aromatic, Plantation, Spices and Forest Crops in the Post Graduate Institute of Post Harvest Technology and Management, Killa Roha, Maharashtra, (18° 42'5947" N, 73°17'9361" E) during the year 2022-2023. The mature dark green coloured chillies of local variety (Konkan Kirti) were collected from farmer's field. The cleaning of green chillies done thoroughly with water and then surface drying was done. Sodium hypochlorite was used for surface sanitization. The drying of green chillies was done in tray dryer for the removal of water content for 18 hours upto the final moisture content reach upto 10±2%. The green chilli powder was packed in standup pouches and stored in ambient conditions at 28℃ and 75% relative humidity (RH).

The process technology was standardized according to the flow chart provided (Fig. 1). The study implemented a Factorial Completely Randomized Design (FCRD) methodology, including eight primary pre-treatments, three storage sub-treatments and three replications. It includes different pre-treatments *viz.*, T1 (Dipping in 1% Ascorbic acid), T2 (Dipping in 1% Sodium chloride), T3 (Dipping in 0.3% Sodium metabisulphite), T4 (Dipping in 1% Ascorbic acid + 1% Sodium chloride + 0.3% Sodium metabisulphite), T5 (Dipping in 0.5% Chitosan), T6 (Dipping in 1% Chitosan), T7 (Blanching at 5 minutes in Boiling water) and T8 (Control) and storage studies at initial, 90 and 180 days. The following various physical and chemical parameters were recorded during the experimentation.

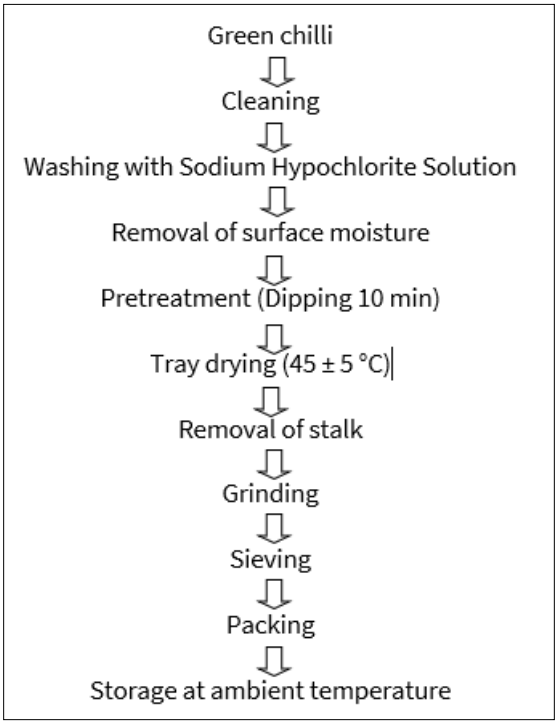

Fig. 1. Diagram showing the steps involved in making green chili powder

Colour (L, a* and b* value)*

The colour of the green chilli powder was measured with the colorimeter (Model CR-400/410 chromameter, Konica Minolta Holdings Inc., Tokyo, Japan) and result was expressed in accordance with the CIE lab system (Hutchings) with reference to illuminate D65 and a viewing angle of 10°. The L*, a*, b* values of the colour of chilli powder was measured accordance to (7).

Solubility (%)

The solubility was calculated according to equation given by (8).

$$\text{Solubility weight (\%)} = \frac{\text{Dried supernatant (g)}}{\text{Weight of sample powder}} \times 100$$

Total Ash (%)

About 5 g of finely ground dried sample was weighed and the ash content of chilli powder sample was determined with method suggested by (9).

$$\text{Totalash (g)} = \frac{\text{Weight of crucible with ash (g) - Weight of crucible (g)}}{\text{Weight of sample taken}} \times 100$$

Fat (%)

Fat content of chilli powder sample was determined with method suggested by (9).

$$\text{Fat (\%)} = \frac{\text{Weight of dried ether soluble material}}{\text{Weight of sample}} \times 100$$

Protein (%)

Protein percent content of chilli powder sample was determined with method suggested by (9).

$$N\% = \frac{\text{(ml HCL-ml blank) x Concentration of HCL}}{\text{Weight of sample (g)}} \times 100$$

% Protein (%) = N% × Factor (6.25)

Crude Fiber (%)

Crude fiber was determined according to (10).

$$\text{Crude fibre (\%)} = \frac{\text{(Dry wt of residue before ashing (g) - wt of residue after ashing (g)}}{\text{Weight of sample (g)}} \times 100$$

pH

pH value of chilli powder sample was determined with method suggested by (9).

Acidity (%)

Titrate acidity percent of chilli powder sample was determined with method suggested by (9).

$$\text{Acidity (\%)} = \frac{\text{Titrate x Normality of alkali x Volume made of x Eq weight of acid x 100}}{\text{Volume of sample taken for estimation x Wt of sample taken x 1000}}$$

Ascorbic acid (mg 100g^{-1})

Ascorbic acid content was estimated by titration method as described by (9) using 2, 6- dichlorophenol indophenol dye solution.

Total phenol content (mg 100g^{-1})

Total phenolic compounds were determined using the Folin-Ciocalteau reagent and gallic acid as a standard (11).

Capsaicin (mg 100g^{-1})

The pungency of chilli samples was determined using the method described by (12).

Total Plate Count (cfu/g)

The total plate count was determined according to the ISO 4833-1:2013 standard method using plate count agar.

Results and Discussion

L* colour value

Table 1 displays the data regarding the impact of various treatments on the L* color value of green chili powder during storage. The L* color value was recorded to determine the lightness to darkness of green chilli powder, which decreased with corresponding increase in the storage in storage period. The greatest mean L* value (45.24) for color was reported in the treatment with 1% Ascorbic acid + 1% sodium chloride + 0.3% sodium metabisulphite. This was on par with treatment T6 (44.24), followed by T2 (43.92). The treatment with 1% ascorbic acid recorded the lowest mean L* value (35.01), followed by T8 (37.93) and T7 (39.84).

In the storage studies, the significantly highest L* value was recorded initially at 0 days (43.46), but it decreased as the storage period progressed. The significant lowest L* value was observed at 180 days of storage (38.87). A significant correlation between the L* value and the various treatments and storage times. The highest L* (46.74) was recorded in pre-treatment with 1% sodium chloride which was on par with T4 (46.60) and T6 (45.99) during the initial 0-day of storage period. In contrast, the lowest L* value (30.98) was reported in treatment with 1% ascorbic acid after 180 days of storage.

The pre-treatment with 1% ascorbic acid + 1% sodium chloride + 0.3% sodium metabisulphite yielded the highest mean L* value for color, whereas the pre-treatment with 1% ascorbic acid alone yielded the lowest mean L* value. The combination treatment (ascorbic acid + sodium chloride + sodium metabisulphite) synergistically prevented browning and enhanced lightness, leading to the highest L* value. On the other hand, ascorbic acid alone provided limited protection against browning, resulting in the lowest L* value. The L* value of the green chili powder declined as the storage duration increased over 180-day period. This indicated that as the storage period lengthened, the color lightness of the green chili powder decreased. The Maillard reaction, which occurs between sugars and amino acids under high temperature during drying or storage, contributes to this decline. While these reactions can enhance desirable flavors and aromas, they also lead to formation of brown pigments that mask the green colour of chilli powder. Similar results were observed by (13) in paprika powder and (14) in dried red pepper.

a* colour value

The data on the effect of different treatments on a* color value of green chilli powder during storage are presented in Table 1. The a* color value was recorded to determine the greenness to redness of green chilli powder, which decreased with corresponding increase in storage period. The blanching treatment (dipping in boiling water for 5 minutes) recorded the significantly highest mean a* value (3.050) for color, followed by T8 (2.136) and T5 (0.513). In contrast, the treatment with 1% ascorbic acid recorded the lowest mean a* value (0.017), followed by T2 (0.151) and T3 (0.174).

With respect to storage, an increasing trend in a* value for color was noticed over the 180-day storage period. The initial stage (0.760) showed the lowest average lowest a* value, whereas the 180th day (0.900) of storage produced the highest average a* value. There was statistical significance in the interaction effects between the storage period and the treatments. The maximum average a* value (2.981) was recorded in the blanching treatment (dipping in boiling water for 5 minutes) at the initial stage, followed by T8 (2.030). The minimum mean a* value (0.017) was observed after 180 days storage in the treatment with 1% ascorbic acid.

The higher a* value for green chilli powder was observed in pre-treatment with blanching (5 minutes in boiling

water), while the lower a* value was observed in the pre-treatment with 1% ascorbic acid. This is attributed to the browning reaction, which involves oxidative and enzymatically controlled processes. A supported result was observed by [13] in paprika powder, which stated that freeze-drying was effective in maintaining the color (pigments) of dried chilli. Similarly, (14) observed significant difference in the a* color value of dried red pepper during a 60 day storage period.

b colour value*

The data for effect of different treatments on b* color value of green chilli powder during storage period are presented in Table 1. The b* color value was recorded to determine yellowness of green chilli powder, which increased with corresponding increase in storage period. The blanching treatment recorded significantly highest mean b* value (22.86) for color, followed by T8 (19.28) and T4 (18.39). In contrast, the treatment with 1% ascorbic acid recorded the lowest mean b* value (15.45) of color, which was on par with T6 (15.50), T3 (16.29) and T5 (16.43). With regard the storage, there was significant increase in the b* value for color during the 180th day of storage period. The average minimum b* value was observed at initial stage (16.43), while the maximum b* value was observed on 180th day of storage (19.03). Interaction between treatments and storage period on b* color value was found to be non-significant at the 5% level of significance.

The pre-treatment with blanching was recorded the significantly highest mean b* value for color, while the pre-treatment with 1% ascorbic acid recorded the lowest mean b* value. This increase in the b* value is attributed to the degradation of chlorophyll pigments responsible for lightness of the green color, causing a shift toward higher b* color values. These observations are in accordance with findings by (13) in paprika powder and (14) in dried red pepper.

Solubility (%)

Table 2 provides information on how various treatments affect the solubility of green chilli powder during storage. The treatment with 1% ascorbic acid recorded the highest mean percentage (7.878%) of solubility, which was on par with T7 (7.867%), followed by T5 (7.767%). In contrast, the treatment T3 and T8 (7.267% each) recorded the lowest mean solubility values, followed by T2 and T6 (7.667% each). A decreasing trend in solubility was observed with an increase in the storage period from 0 to 180 days. The data was found to be significant. At 0 days of storage, the solubility percentage was 7.929%, whereas it was decreased to 7.213% after 180 days of storage. The interaction between treatments and storage period was significant at the 5% level. The maximum solubility (8.233%) was recorded for T1 at 0 days, followed by T7 (8.200%). In contrast, the minimum solubility was observed in treatments T3, T4 and T8 (6.900% each) at 180 days of storage.

The pre-treatment with 1% ascorbic acid recorded highest mean solubility, which was on par with blanching for 5 minutes in boiling water, while the control recorded lowest mean solubility. The slight decrease in solubility of green chilli powder was attributed to a slight increase in absorption, leading to clumping and a resultant decrease in solubility. Similar results were observed by [16] in *Rujak cingur* spices powder.

Total Ash (%)

The data for effect of different treatments on total ash percent of green chilli powder during storage period are presented in Table 2. The treatment with 1% ascorbic acid recorded the significantly highest mean (6.90%) total ash percentage followed by treatments T4 (6.57%), T3 (5.67%) and T5 (5.67 %). In contrast, the treatment T2 (4.50%) recorded significantly lowest mean value of ash percentage. With regards to storage there was decrease in total ash percentage with an increase in the storage period. The total ash percentage on initial day was found to be 5.98% which was decreased to 5.47% at 180 days storage. The interaction between different treatments and storage period was found to be significant. The maximum total ash percentage (7.10%) was found in treatment with 1% ascorbic acid at 0 days and minimum was observed in treatment T2 (4.30%) on 180 days. The higher total ash in green chilli powder was observed with pre-treatment with 1% ascorbic acid and lower total ash was observed with 1% sodium chloride. The variability in total ash contents may be

Table 1. Effect of different treatments and storage period on L*, a* and b* colour value of green chilli powder

Treatments	L* colour value				a* colour value				b* colour value			
	Storage period (days)				Storage period (days)				Storage period (days)			
	0	90	180	Mean	0	90	180	Mean	0	90	180	Mean
T1	39.02	35.02	30.98	35.01	0.016	0.017	0.017	0.017	13.84	15.69	16.80	15.45
T2	46.74	44.13	40.88	43.92	0.121	0.149	0.182	0.151	15.78	17.98	19.65	17.80
T3	44.37	42.83	37.80	41.67	0.161	0.173	0.189	0.174	14.76	16.93	17.16	16.29
T4	46.60	45.65	43.48	45.24	0.231	0.252	0.261	0.248	17.45	18.29	19.44	18.39
T5	43.31	42.14	41.59	42.35	0.321	0.487	0.731	0.513	15.80	16.50	17.00	16.43
T6	45.99	44.13	42.59	44.24	0.217	0.343	0.407	0.322	14.63	15.14	16.74	15.50
T7	41.55	39.84	38.13	39.84	2.981	3.002	3.150	3.050	20.73	22.71	25.14	22.86
T8	40.13	38.13	35.51	37.93	2.030	2.110	2.152	2.136	18.40	19.13	20.32	19.28
Mean	43.46	41.48	38.87		0.760	0.817	0.900		16.43	17.80	19.03	
	S.Em±		CD at 5 %		S.Em±		CD at 5 %		S.Em±		CD at 5 %	
Treatments (T)	0.39		1.13		0.001		0.003		0.41		1.18	
Storage (S)	0.24		0.69		0.001		0.002		0.25		0.72	
Interaction (T×S)	0.68		1.95		0.002		0.005		0.72		NS	

Table 2. Effect of different treatments and storage period on Solubility, Total Ash and fat value of green chilli powder

Treatments	Solubility (%)				Total Ash (%)				Fat (%)			
	Storage period (days)				Storage period (days)				Storage period (days)			
	0	90	180	Mean	0	90	180	Mean	0	90	180	Mean
T1	8.233	7.900	7.500	7.878	7.1	6.9	6.7	6.90	5.96	5.95	5.93	5.95
T2	8.000	7.700	7.300	7.667	4.70	4.50	4.30	4.50	4.72	4.72	4.65	4.70
T3	7.600	7.300	6.900	7.267	5.90	5.70	5.40	5.67	7.28	7.23	7.20	7.24
T4	7.700	7.400	6.900	7.767	6.80	6.60	6.30	6.57	6.08	6.06	6.01	6.05
T5	8.100	7.800	7.400	7.767	5.90	5.70	5.40	5.67	5.92	5.89	5.84	5.88
T6	7.000	7.700	7.300	7.667	5.90	5.57	5.33	5.60	5.78	5.76	5.87	5.80
T7	8.200	7.900	7.500	7.867	5.80	5.40	5.10	5.43	3.10	3.08	3.06	3.08
T8	7.600	7.300	6.900	7.267	5.70	5.40	5.20	5.43	6.12	6.09	6.07	6.09
Mean	7.929	7.625	7.213		5.98	5.72	5.47		5.62	5.60	5.58	
	S.Em±		CD at 5 %		S.Em±		CD at 5 %		S.Em±		CD at 5 %	
Treatments (T)	0.004		0.011		0.009		0.02		0.008		0.02	
Storage (S)	0.002		0.007		0.005		0.01		0.005		0.01	
Interaction (T×S)	0.007		0.019		0.015		0.04		0.015		0.04	

due to organic matter which degraded and separated from powder, lead to decrease in ash percentage during storage. The similar result for total ash content during storage reported by [15] in soyabean.

Fat (%)

The data for effects of treatments on fat content of green chilli powder during storage period are presented in Table 2. Treatment with 0.3% sodium metabisulphite recorded the significantly highest mean (7.24%) fat percentage which was followed by T8 (6.09%) and T5 (6.05 %). In contrast, treatment T7 (3.08%) recorded the lowest fat mean in green chilli powder followed by T2 (4.70%) and T6 (5.80%). In the storage studies significantly maximum fat percentage was observed at 0 days (5.62%) and was decreased with increase in storage period to 5.58% at 180 days. The result observed in the interaction of different treatments and storage period was observed to be significant**.** The maximum fat percentage (7.28%) was recorded in treatment with 0.3% sodium metabisulphite which was followed by treatment T8 (6.12%) at 0 days. In contrast, the lowest fat percentage was observed in T7 (3.06) at 180 days. Fat percentage in green chilli powder decreased with increasing in storage period of 180 days due to the oxidation processes. Similar result for decreasing fat percentage during storage were observed by [17] in red chilli.

Protein (%)

The data for effect of different treatments on protein percent of green chilli powder during storage period are presented in Table 3. The treatment with 0.3% sodium metabisulphite recorded the significantly highest mean protein (22.17%) which was followed by T1 (21.37%), whereas T8 (12.61%) recorded the lowest protein content which was on par with T2 (12.85%). During the storage studies there was significant decrease in protein throughout the storage of 180 days. At initial day of storage, the maximum mean of protein was 18.41% which was decreased to 15% at 180 days. Interaction between treatments and storage period on protein of chilli powder was found to be significant at 5% level. The highest protein (23.62%) was found in treatment with 0.3% sodium metabisulphite on 0 days, while lowest protein content was found in T8 (10.02%), followed by T7 (11.18 %). Protein loss is mainly due to free radical protein reactions which are produced from the oxidization of lipids. As the water content increases, the radicles are quenched, reducing reaction rate and water also act as an antioxidant in dry foods, which resulted into protein loss during storage. Identical result for decreasing trend of protein value during storage were observed by (18) in soyabean during storage period.

Crude fiber (%)

The data for effect of different treatments on crude fiber content of green chilli powder during storage period are presented in Table 3. The treatment with 1% ascorbic acid recorded the significantly highest crude fiber mean (27.200%), followed by T5 (25.633%) and T2 (25.167%). In contrast, the treatment T7 (17.400%) recorded the lowest crude fiber mean, followed by T8 (19.700%) and T3 (21.933%). A significant decrease in the crude fiber content was observed during storage period of 180 days. The highest crude fiber mean was recorded at 0 days (24.125 %) irrespective to the treatments while the lowest crude fiber mean was observed on 180 days (21.950%). Interaction between treatments and storage period on crude fiber mean on green chilli powder was significant. The highest crude fiber average (27.600%) was observed in treatment with 1% ascorbic acid, followed by treatment T5 (27.300%) at 0 days and the lowest crude fiber was recorded in T7 (16.500%) at 180 days. Increasing moisture content create a favourable environment for microbial growth and enzymatic activities, both of which break down complex molecules into simpler forms, which resulted the decrease in crude fiber content. Similar finding were observed by (15) in soybean during storage.

pH value

The data for effect of different treatments on pH value of green chilli powder during storage period are presented in Table 3. The pH of green chilli powder was decreased with corresponding increase in storage period. The blanching recorded the significantly highest mean (5.42) pH value followed by T3 (5.22), while treatment T1 and T4 (5.14) both observed the lowest pH values, followed by T5 and T8 (5.16 each). There was a significant difference in storage from 0 to 180 days to pH value. During storage the highest pH value was recorded at 0 days (5.23) of storage, while the lowest (5.16) was observed at 180 days. Interaction between the treatments and storage period of chilli powder for pH value was found to be non-significant, because glucose and fructose are transformed

Table 3. Effect of different treatments and storage period on Protein, Crude Fiber and pH value of green chilli powder

Treatments	Protein (%)				Crude Fiber (%)				pH value			
	Storage period (days)				Storage period (days)				Storage period (days)			
	0	90	180	Mean	0	90	0	Mean	0	90	180	Mean
T1	22.57	21.94	19.61	21.37	27.600	27.200	26.800	27.200	5.17	5.17	5.17	5.17
T2	13.82	13.03	11.68	12.85	25.700	25.600	24.200	25.167	5.21	5.17	5.21	5.17
T3	23.62	22.72	20.18	22.17	23.400	22.600	19.800	21.933	5.23	5.23	5.23	5.23
T4	18.64	16.97	14.97	16.86	25.600	24.500	23.200	24.433	5.17	5.17	5.17	5.17
T5	15.29	13.98	12.96	14.08	27.300	25.900	23.700	25.633	5.17	5.17	5.17	5.17
T6	21.15	20.33	19.38	20.29	24.100	23.570	22.800	23.490	5.20	5.17	5.20	5.17
T7	16.64	14.64	11.18	14.15	18.600	17.100	16.500	17.400	5.47	5.43	5.47	5.43
T8	15.52	12.28	10.02	12.61	20.700	19.800	18.600	19.700	5.20	5.17	5.20	5.17
Mean	18.41	16.99	15.00		24.125	23.284	21.950		5.23	5.21	5.23	
	S.Em±		CD at 5 %		S.Em±		CD at 5 %		S.Em±		CD at 5 %	
Treatments (T)	0.18		0.52		0.015		0.043		0.03		0.08	
Storage (S)	0.11		0.32		0.009		0.026		0.02		0.05	
Interaction	0.32		0.91		0.026		0.075		0.05		Non-Significant	

to carbon dioxide and alcohol, which can then hydrolyse to produce oxygen and acetic acid, it is possible that this is the cause of the pH decline in preserved samples. Similar results were found with the pH value during storage were observed by (18) in green chilli powder and (19) in green chilli paste.

Acidity (%)

The data for acidity content of green chilli powder during storage period are presented in Table 4. Acidity is the total amount of acid in the solution or sample. Hydrolysis of polysaccharides is the main reason for changes in acidity. The treatment with 1% ascorbic acid recorded the significantly highest mean (0.997%) acidity followed by T4 (0.953%), while T7 (0.337%) recorded the lowest mean acidity followed by T3 (0.717 %). The mean acidity during storage of 0 to 180 days was increased significantly. The lowest acidity content was observed at 0 day (0.749%), while the highest mean acidity was at 180 day (0.815 %) of storage. The interaction was found to be significant between treatments and storage of green chilli powder. The lowest acidity content was noticed in treatment T7 (0.290 %) at 0 days, while the highest acidity content (1.020%) was observed with treatment 1% ascorbic acid, followed by T4 (0.990 %) at 180 days. Acidity is the total amount of acid in the solution or samples. Hydrolysis of polysaccharide is the main reason for changes in acidity. Citric acid is the main organic acid present in chilli, the increase in acidity content of green chilli powder was due to decrease in pH value. Similar result for increasing trend of acidity in green chilli was reported by (19).

Ascorbic acid (mg 100g^{-1})

The data for effect of different treatments on ascorbic acid content of green chilli powder during storage period are presented in Table 4. The treatment with 1% ascorbic acid recorded the significantly highest mean (125.35 mg 100g^{-1}) ascorbic acid value followed by T4 (117.34 mg 100g^{-1}) and T5 (116.01 mg 100g^{-1}), whereas the treatment T7 (105.47 mg 100g^{-1}) recorded the lowest mean value followed by T8 (109.21 mg 100g^{-1}) and T3 109.86 mg 100g^{-1}). As regards, storage conditions, decrease in ascorbic acid value was observed during 180 days. The ascorbic acid significantly decreased from 124.16 mg 100g^{-1} at the initial stage to 100.90 mg 100g^{-1}at 180 days of storage. Interaction between different treatments and storage period on ascorbic acid value of green chilli powder was found to be non-significant. Given the abundance of research indicating ascorbic acid considerable heat sensitivity, the decline in ascorbic acid content was rather predictable. Similar result for decreasing trend of ascorbic acid were observed by (20) in green chilli powder.

Table 4. Effect of different treatments and storage period on Acidity, Ascorbic acid, Total phenol of green chilli powder

Treatments	Acidity (%)				Ascorbic Acid (mg 100g^{-1})				Total Phenol (mg 100g^{-1})			
	Storage period (days)				Storage period (days)				Storage period (days)			
	0	90	180	Mean	0	90	180	Mean	0	90	180	Mean
T1	0.940	0.960	1.020	0.997	131.83	128.07	116.16	125.35	36.94	35.56	34.14	35.55
T2	0.720	0.730	0.750	0.733	122.90	112.00	100.97	111.96	34.60	33.84	32.24	33.56
T3	0.680	0.720	0.750	0.717	120.53	111.10	97.93	109.86	32.25	31.46	29.96	31.22
T4	0.920	0.950	0.990	0.953	129.17	119.00	103.84	117.34	33.69	32.58	31.12	32.46
T5	0.860	0.890	0.940	0.897	126.77	119.53	101.73	116.01	28.95	27.14	25.22	27.10
T6	0.740	0.750	0.790	0.760	124.70	117.90	97.53	113.38	35.91	34.64	33.96	34.83
T7	0.290	0.330	0.390	0.337	117.93	106.67	91.80	105.47	16.38	13.58	11.78	13.91
T8	0.840	0.860	0.890	0.863	119.47	110.93	97.23	109.21	25.84	24.53	23.87	24.75
Mean	0.749	0.774	0.815		124.16	115.65	100.90		30.57	29.17	27.79	
	S.Em±		CD at 5 %		S.Em±		CD at 5 %		S.Em±		CD at 5 %	
Treatments (T)	0.002		0.005		1.29		3.67		0.35		1.00	
Storage (S)	0.001		0.003		0.79		2.24		0.24		0.61	
Interaction (T×S)	0.003		0.014		2.23		Non-Significant		0.61		Non-Significant	

Total phenol content (mg 100g^{-1})

The data for effect of different treatments on total phenol content of green chilli powder during storage period are presented in Table 4. The treatment with 1% ascorbic acid recorded the highest mean (35.55 mg 100g^{-1}) total phenol content which was on par T6 (34.83 mg 100g^{-1}), followed by T2 (33.56 mg 100g^{-1}), whereas treatment T7 (13.91 mg 100g^{-1}) recorded the lowest mean total phenol content followed by T8 (24.75 mg 100g^{-1}) and T5 (27.10 mg 100g^{-1}). Total phenol content during storage of 0 to 180 days also decreased significantly. The storage had a significant effect on the total phenol content of green chilli powder during 180 days of storage. At 0 days the total phenol content was 30.57 mg 100g^{-1} and it was decreased up to 27.79 mg 100g^{-1} 180 days during storage. The interaction effect of behaviour between different treatments and storage periods on total phenol content of green chilli powder was statistically non-significant. Enzyme in green chilli powder naturally contains enzyme like polyphenol oxidize (PPO). These enzymes can oxidize into phenolic compound under storage condition, break down their structure and that reduce their overall presence. Similar result for decreasing trend of total phenols were observed by (21) in sorghum grain and flour.

Capsaicin (mg 100g^{-1})

The data for effect of different treatments on capsaicin content of green chilli powder during storage period are presented in Table 5. The treatment with 1% ascorbic acid recorded the significantly highest mean (31.69 mg 100g^{-1}) capsaicin value followed by T2 (28.50 mg 100^{g-1}) and T7 (28.44 mg 100g^{-1}), whereas the treatment T3 (17.62 mg 100g^{-1}) recorded the lowest mean capsaicin content followed by T5 (25.81 mg 100g^{-1}) and T8 (26.20 mg 100g^{-1}). A decrease in capsaicin content was observed during 180 days of storage. The capsaicin significantly decreased from 27.78 mg 100g^{-1} at the initial stage to 25.71 mg 100g^{-1} at 180 days of storage. Interaction between different treatments and storage period on capsaicin content of green chilli powder was found to be significant. The maximum capsaicin was observed in the treatment T1 (32.45 mg 100g^{-1}) followed by T7 (29.99 mg 100g^{-1}) at initial day of storage. After 180 days of storage period, the minimum capsaicin was observed in the treatment T3 (16.27 mg 100g^{-1}), followed by T5 (24.98 mg 100g^{-1}). Capsaicin is an active component in chilli and pungency of chilli is due to presence of capsaicin. The reason for the gradual decrease in capsaicin after storage could be attributed to its sensitivity to oxygen, light and moisture when kept in an ambient environment (22). Green chilli powder contains enzyme like capsaicinase, that break down the capsaicin molecules into less pungent compounds. Increase in moisture percentage during storage period activates this enzyme and accelerate capsaicin degradation. The data in accordance with this result for decreasing trend of capsaicin content during storage at ambient condition were observed by (22).

Total plate count (cfu/g)

The data for effect of different treatments on total plate count of green chilli powder during storage period are presented in Table 5. Total plate count is the method of estimating the total number of microorganisms in sample. The treatment T5 (0.627 × 10^2) recorded the significantly highest mean total plate count, followed by T8 (0.613 × 10^2). In contrast, treatment with 1% ascorbic acid + 1% sodium chloride + 0.3% sodium metabisulphite observed the significantly lowest mean (0.56 × 10^2) total plate count. There was significant increase in the total plate count content was observed during 180 days of storage period after 90 days but it is in permissible limit. The initially up to 90 days total plate count was not detected. The average maximum total plate count was found on 180 days of storage (1.78 cfu × 10^2/g). Interaction between different treatments and storage period on total plate count content of chilli powder was found to be significant. Thermal processing of spices, hygienic practices during processing and storage and antibacterial actions were determined to be the cause of total plate count. Similar findings for raise in the total plate count for was reported by (23) in spice mix formulation.

Conclusion

Table 5. Effect of different treatments and storage period on capsaicin content and total plate count of green chilli powder

Treatments	Capsaicin content (mg 100g^{-1})				Total plate count (cfu/g)			
	Storage period (days)				Storage period (days)			
	0	90	180	Mean	0	90	180	Mean
T1	32.45	31.74	30.88	31.69	ND	ND	1.78× 10^2 (3.25)	0.593×10^2 (2.77)
T2	29.17	29.00	27.32	28.50	ND	ND	1.82×10^2 (3.26)	0.607×10^2 (2.78)
T3	18.67	17.94	16.27	17.62	ND	ND	1.76×10^2 (3.25)	0.587×10^2 (2.77)
T4	28.40	28.40	27.47	28.09	ND	ND	1.68×10^2 (3.23)	0.560×10^2 (2.75)
T5	26.72	25.73	24.98	25.81	ND	ND	1.88×10^2 (3.27)	0.627×10^2 (2.80)
T6	29.69	27.98	26.43	28.03	ND	ND	1.72×10^2 (3.24)	0.573×10^2 (2.76)
T7	29.99	28.01	27.33	28.44	ND	ND	1.75×10^2 (3.24)	0.583×10^2 (2.77)
T8	27.13	26.44	25.03	26.20	ND	ND	1.84×10^2 (3.26)	0.613×10^2 (2.79)
Mean	27.78	26.91	25.71		0	0	1.78×10^2 (3.25)	
	S.Em±		CD at 5 %		S.Em±		CD at 5 %	
Treatments (T)	0.02		0.07		0.002		0.005	
Storage (S)	0.01		0.04		0.001		0.003	
Interaction (T×S)	0.04		0.12		0.003		0.01	

*Bracket value indicate $\log_{10}$ value

ND = Not Detected

Based on the finding in current studies, it is concluded that the pre-treatment with dipping of green chillies for 10 min in 1% ascorbic acid exhibits better quality of green chilli powder as compared to other pre-treatments and has acceptable quality upon storage at ambient condition for 180 days.

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Authors' contributions

SDP conducted of the experiment and acquisition of data, analysis and interpretation of the data, JHK made substantial contribution to conception and designing of the experiment, overall guidance to conduct of the experiment, GDS involved in statistical analysis and providing laboratory facilities and SST involved in the time to time guidance during the conduct of experiment and revising the manuscript, PUS involved in drafting the manuscript critically for important intellectual content.

Compliance with ethical standards

Conflict of interest: All the authors of manuscript entitled 'Effect of pre-treatments and storage on quality of green chilli powder' are hereby declared that we do not have any conflict of interests to declare.

Ethical issues: None

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