EFFECT OF DIFFERENT PRE-TREATMENTS AND DRYING TECHNIQUES ON QUALITY OF CAULIFLOWER

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Abstract
Fruits and vegetables are dried to enhance storage stability, minimize packaging requirement and reduce transport weight. Energy consumption and quality of dried products are critical parameters in the selection of drying process. An optimum drying system for the preparation of quality dehydrated products is cost effective as it shortens the drying time and cause minimum damage to the product. Dehydration process was carried out for cauliflower after giving different pre-treatments such as calcium chloride (1.0 % $CaCl_2$), potassium metabisulphite (1.0 % KMS) and sodium chloride (1.0% NaCl) for a period of 21 days. Untreated samples served as control. Solar drier and cabinet dryer were used for dehydration. Quality characteristics of cauliflower slices viz. moisture content, ascorbic acid, rehydration ratio and non-enzymatic browning as affected by dehydration process were studied. Minimum moisture content was shown by dehydrated cauliflower treated with 1.0% KMS in both drying methods and maximum moisture was found in dehydrated cauliflower treated with 1.0% $CaCl_2$ due to its hygroscopic nature. Also, minimum value of browning was obtained from 1.0% KMS treated dehydrated cauliflower during the 21 days storage. Among the different drying methods, cabinet dried samples treated with different pre-treatments showed maximum value of ascorbic acid. Rehydration ratio was highest in 1.0% KMS treated dehydrated cauliflower samples. Maximum browning was found in control samples during the course of storage. Minimum browning was found in 1.0% KMS followed by 1.0% $CaCl_2$ and 1.0% NaCl in both drying methods.

Keywords: KMS, $CaCl_2$, NaCl, rehydration ratio, sun drying, cabinet drying

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1. INTRODUCTION

The preservation of fruits and vegetables by dehydration offers a unique challenge. Due to the structural configuration of these products, the removal of moisture must be accomplished in a manner that will be least detrimental to the product quality. Cauliflower (*Brassica oleracea*, var. *botrytis*), is an important Cole crop and belong to Cruciferous family. It is an important vegetable grown all over the world. Cauliflower occupies an area of 8.88 million ha, having a production of 16.40 million tonnes in the world (FAOSTAT, Database, 2004). India alone accounts for nearly 30% of the total world area and about 28% of the total world production of cauliflower. Cauliflower has the highest waste index, i.e. ratio of non-edible to edible portion after harvesting and thus generates a large amount of organic solid waste, which creates a foul odour on decomposition (Kulkarni *et al.*, 2001).

Cauliflower is low in fat and carbohydrates but high in dietary fiber, folate, water, and vitamin C, containing many health beneficial phytochemicals such as glucosinolates, vitamin C and phenolic compounds. *Brassica* vegetables in general protect humans against lung, gastrointestinal tract and prostrate cancer. Indole-3-carbinol, a chemical that enhances DNA repair and acts as an estrogen antagonist is slowing the growth of cancer cells. A high intake of Cruciferous vegetables has been associated with reduced risk of prostate cancer, therefore a growing and urgent need for simple, inexpensive processes that would offer a way to save these highly perishable commodities from spoilage (Sujatha *et al.*, 2014). It can be abundantly produced from April to December in the maritime Northeast. Soil with rich humus is crucial because cauliflower tends to have weak root systems. This plant likes mild summer climates (around 80-90^{o}F).

Fresh cauliflower has 92 to 94% water and it can be stored for 2 to 4 weeks at 0°C. Processing of cauliflower can be an alternate for extending the shelf life. The most serious constraint for shelf-life enhancement is the activity of micro-organisms and the physiological nature of the crop which leads to 49% losses per hectare (Sehgal, 1999).
Dehydration is one of the oldest methods of food preservation and an important food processing stage (Lima *et al*., 2002). Dehydration of foods is aimed at producing a high-density and high-quality product, which, when adequately packaged has a long shelf life, after which the food can be rapidly reconstituted without substantial loss of flavor, taste, color and aroma (Sarsavadia *et al*., 1999). Drying involves the application of heat to vaporize the volatile substances (moisture) and some means of removing water vapor after its separation from the solid (Jayamaran and Gupta, 2006). Dehydrated cauliflower can be used to enhance the test and nutritional value of various products such as rehydrated vegetable mix, soups, canned products, extruded products etc. The objectives of the present investigation were: (a) enhancement of shelf life of cauliflower by dehydration; (b) to study the effect of different pre-treatments on quality attributes of dried cauliflower; and (c) to carry out storage studies in relation to pre-treatments and drying techniques of cauliflower.

2. MATERIALS AND METHODS

2.1 Drying of the cauliflower

Cleaning and trimming of procured fresh cauliflower were done manually and edible cauliflower curd was sized to florets (3.0 to 4.5 cm) using stainless steel knife after removing non-edible leaves and stem. Cut florets were weighed on electronic weighing balance and washed in tap water.

2.2 Blanching

Boiling water method was used for blanching the washed cauliflower. It was achieved by tying the cauliflower pieces in a muslin cloth and dipping it into boiling water for a specified duration of 3 min. The samples were then cooled in tap water to avoid over cooking and discoloration.

2.3 Pre-treatments

Blanched and cooled cauliflower samples were dipped in:

T_1: Potassium metabisulphite (KMS) 1.0%
T_2: Calcium Chloride ($CaCl_2$) 1.0%
T_3: Sodium Chloride (NaCl) 1.0%

After 15 minutes of dip the samples were drawn out of the preservative solution drained for few minutes. The drained samples were segregated into the equal parts one part was used for drying in a cabinet dryer and 2nd for sun drying.

Methods

2.4 Physico-Chemical Properties

2.4.1 Moisture Content

Moisture content was determined by AOAC (2005) method; ascorbic acid by using the method developed by Ranganna (1992); rehydration ratio by keeping the dehydrated product in boiling water for 15-min duration so as to restore the fresh-like appearance of the dehydrated product. It is the ratio of the weight of dehydrated cauliflower to the weight of rehydrated cauliflower.
f the weight of the dehydrated sample is A and the drained weight of the rehydrated sample is B, then RR can be written as:

$$RR \quad A = B \quad A: B$$

Non enzymatic browning was determined according to the method of Ranganna (1986).

Statistical Analysis

The data obtained for each parameter was statistically analysed. Statistical analysis was done using OPSTAT software.

3. RESULTS AND DISCUSSION

Effect of various pre-treatments and different drying methods on moisture content of cauliflower

Data regarding the moisture content of sun dried and cabinet dried samples with pre-treatments revealed that the maximum mean moisture content (12.56%) was noticed in sun drying and minimum (6.47%) was noticed in cabinet drying. The effect of pre-treatments on both sun and cabinet dried samples was significant (P<0.05). Table -1 depicted that mean values of moisture content of control and all the pre-treated sun dried cauliflower samples showed an increased trend from (12.47% - 12.63%) throughout the storage period. Highest mean moisture content was recorded in T_2 (12.88%) followed by T_3 (12.76%) while the lowest was recorded in T_1 (12.17%) followed by control sample (12.41%).

Mean moisture content of cabinet dried cauliflower samples of control as well as pre-treated samples showed a slight increasing trend throughout the period of storage which ranged from (6.39%-6.55%). Highest mean moisture content was noticed for T_2 (6.83%) followed by T_3 (6.58%) while the lowest mean moisture content was noticed for T_1 (6.17%) followed by control samples (6.30%).

The maximum value of moisture for T_2 and T_3 treated samples is attributed to their hygroscopic nature.

Among both the drying methods, T_1 showed minimum moisture gain during storage (Table 1). Similar result was found in dehydrated cauliflower by Kadam *et al.,* 2006.

Effect of various pre-treatments and different drying methods on ascorbic acid content of cauliflower

Data regarding the ascorbic acid (vitamin C) is presented in Table 2. Cabinet drying showed highest mean ascorbic acid (312.46 mg/100g) than sun drying (266.88 mg/100g).

The effect of different pre-treatments on ascorbic acid of dried cauliflower samples was significant (P<0.05).

The results of ascorbic acid (mg/100g) of sun dried cauliflower revealed that there was a drastic decrease in it after 7^{th} day in all the treatments which may be attributed to oxygen permeability of package, which is an essential element in the loss of vitamin C. These results are in line with the findings of Chauhan *et al*., (1998) with maximum decrease recorded in T_0 while minimum was recorded in T_1. This is because ascorbic acid is a very reactive compound and is particularly vulnerable to storage.

Maximum retention of mean ascorbic acid (291.47 mg/100g) was noticed in KMS (1.0%) pre-treated samples while minimum in control (239.12 mg/100g).

The mean ascorbic acid (mg/100g) content of cabinet dried cauliflower of control as well as pre-treated samples also showed a significant decreasing trend with maximum decrease recorded in T_0 while minimum was recorded in $T_{1.}$ Maximum retention of ascorbic acid was noticed in T_1 (368.40mg/100g) followed by T_2 (322.03mg/100g) while minimum was recorded in T_0 (262.58mg/100g) followed by T_3 (296.81mg/100g).

Among both the drying methods KMS pre-treatment showed maximum retention of ascorbic acid and minimum in control. This might be due to higher retention of SO_2 in T_1 samples which minimize the oxidative loss of ascorbic acid by acting as reducing agents. These results are in line with the findings of Sarabjeet *et al*., (2011).

Cauliflower lost ascorbic acid during drying, but dried cauliflower showed higher percentage of ascorbic acid than fresh cauliflower.

This is because as moisture evaporates, the ascorbic acid gets concentrated in the dehydrated cauliflower.

Similar results were found in dehydrated cauliflower by Kadam *et al*., (2006).

Table 1: Effect of various pre-treatments and different drying methods on moisture content of cauliflower

Pre-treatment	Sun drying (Days)				Mean	Cabinet drying (Days)				Mean	Grand mean
	0	7	14	21		0	7	14	21		
Control (T_0)	12.33±0.04	12.39±0.03	12.44±0.04	12.49±0.04	**12.41**	6.21±0.03	6.28±0.03	6.33±0.03	6.38±0.02	**6.30**	**9.36**
KMS (T_1)	12.10±0.39	12.16±0.03	12.21±0.03	12.26±0.03	**12.17**	6.10±0.03	6.16±0.02	6.20±0.03	6.25±0.03	**6.17**	**9.17**
$CaCl_2$ (T_2)	12.80±0.03	12.86±0.03	12.91±0.02	12.96±0.03	**12.88**	6.76±0.02	6.81±0.02	6.86±0.02	6.90±0.02	**6.83**	**9.86**
NaCl (T_3)	12.68±0.03	12.74±0.04	12.79±0.02	12.84±0.03	**12.76**	6.50±0.02	6.56±0.02	6.60±0.02	6.68±0.02	**6.58**	**9.67**
Mean	**12.47**	**12.53**	**12.58**	**12.63**		**6.39**	**6.45**	**6.49**	**6.55**		
			12.56					**6.47**			

CD $_{(p<0.05)}$

Pretreatments = 0.060 Storage period = 0.060
Dehydration Technique = NS Pretreatment × Storage Period = NS
Pretreatments × Dehydration Technique = NS Storage Period × Dehydration Technique = NS
Pretreatments × Storage Period × Dehydration Technique = NS

The data are presented as average of triplicates ± standard deviation.

Table-2: Effect of various pre-treatments and different drying methods on ascorbic acid content of cauliflower

Pre-treatment	Sun drying (Days)				Mean	Cabinet drying (Days)				Mean	Grand mean
	0	7	14	21		0	7	14	21		
Control (T_0)	252.89±3.0	240.72±2.00	233.22±2.08	179.33±2.51	239.12	330.13±2.51	284.71±2.0	244.62±2.0	190.84±2.0	262.58	250.85
KMS (T_1)	306.80±2.0	296.72±2.00	288.21±2.00	274.13±2.00	291.47	430.13±2.00	382.48±2.0	360.22±2.0	300.79±2.0	368.40	329.94
$CaCl_2$ (T_2)	290.74±2.0	264.62±3.05	255.71±2.00	240.44±2.00	278.41	385.92±2.00	340.71±2.0	300.98±7.0	260.51±2.51	322.03	300.22
NaCl (T_3)	272.89±2.0	264.62±2.00	255.71±2.00	240.44±2.00	258.42	362.33±2.00	320.71±2.0	274.11±2.0	230.10±2.51	296.81	277.62
Mean	280.83	271.10	262.98	252.58	-	377.13	332.15	294.98	245.56		-
		266.88					312.46				

CD $_{(p<0.05)}$

Pretreatments = 0.554 Storage period = 0.554
Dehydration Technique = 0.392 Pretreatment × Storage Period = 1.107
Pretreatments × Dehydration Technique = 0.783 Storage Period × Dehydration Technique = 0.783
Pretreatments × Storage Period × Dehydration Technique = 1.566

The data are presented as average of triplicates± standard deviation.

Table-3: Effect of various pre-treatments and different drying methods on rehydration ratio content of cauliflower

Pre-treatment	Sun drying (Days)				Mean	Cabinet drying (Days)				Mean	Grand mean
	0	7	14	21		0	7	14	21		
Control (T_0)	6.58±0.02	6.48±0.04	6.36±0.02	6.29±0.02	**6.42**	7.40±0.02	7.38±0.02	7.30±0.02	7.28±0.03	**7.34**	**6.88**
KMS (T_1)	6.9±0.41	6.81±0.03	6.72±0.02	6.64±0.02	**6.76**	7.66±0.02	7.54±0.02	7.46±0.02	7.40±0.02	**7.51**	**7.14**
$CaCl_2$ (T_2)	6.72±0.02	6.61±0.02	6.54±0.02	6.46±0.02	**6.58**	7.50±0.02	7.41±0.02	7.36±0.02	7.30±0.02	**7.39**	**6.99**
NaCl (T_3)	6.66±0.03	6.54±0.02	6.44±0.02	6.34±0.03	**6.49**	7.48±0.03	7.36±0.02	7.29±0.03	7.22±0.02	**7.33**	**6.91**
Mean	**6.71**	**6.61**	**6.51**	**6.43**	- -	**7.51**	**7.42**	**7.35**	**7.30**		-
		6.57					**7.39**				

CD $_{(p<0.05)}$

Pretreatments = 0.044 Storage period = 0.044
Dehydration Technique = 0.031 Pretreatment × Storage Period = 0.088
Pretreatments × Dehydration Technique = NS Storage Period × Dehydration Technique = NS
Pretreatments × Storage Period × Dehydration Technique = 0.124
The data are presented as average of triplicates ± standard deviation.

Table-4: Effect of various pre-treatments and different drying methods on browning (optical density) of cauliflower

Pre-treatment	Sun drying (Days)				Mean	Cabinet drying (Days)				Mean	Grand mean
	0	7	14	21		0	7	14	21		
Control (T_0)	0.0584±0.0002	0.0973±0.0001	0.1733±0.0002	0.3390±0.0025	**0.1657**	0.0503±0.0002	0.0713±0.0002	0.1413±0.0002	0.2311±0.0002	**0.1235**	**0.1446**
KMS (T_1)	0.0002±0.0001	0.0017±0.0002	0.0105±0.0002	0.0274±0.0002	**0.0100**	0.0000±0.0001	0.0007±0,0002	0.0095±0.0002	0.0163±0.0002	**0.0066**	**0.0083**
$CaCl_2$ (T_2)	0.0013±0.0002	0.0113±0.0002	0.0934±0.0002	0.1713±0.0001	**0.0693**	0.0006±0.0002	0.0045±0.0002	0.0534±0.0002	0.1132±0.0002	**0.0429**	**0.0561**
NaCl (T_3)	0.0083±0.0002	0.0143±0.0002	0.1213±0.0002	0.2432±0.0002	**0.0968**	0.0022±0.0002	0.0098±0.0001	0.0782±0.0002	0.1512±0.0002	**0.0604**	**0.0786**
Mean	**0.017**	**0.031**	**0.099**	**0.194**		**0.013**	**0.021**	**0.070**	**0.128**		-
		0.0856					**0.058**				

CD $_{(p<0.05)}$

Pretreatments = 0.001 Storage period = 0.002
Dehydration Technique = 0.001 Pretreatment × Storage Period = 0.002
Pretreatments × Dehydration Technique = 0.002 Storage Period × Dehydration Technique = 0.003
Pretreatments × Storage Period × Dehydration Technique = 0.003
The data are presented as average of triplicates ± standard deviation.

Effect of various pre-treatments and different drying methods on rehydration ratio content of cauliflower

From the Table 3, it was depicted that mean value of rehydration ratio of control and all the pre-treated samples differed significantly ($P<0.05$). It was observed that the minimum mean rehydration ratio (6.57%) was obtained in sun drying and maximum (7.39%) for cabinet drying

All the sun dried cauliflower samples showed a progressive decrease in the rehydration ratio throughout the period of storage. The decrease in the mean rehydration ratio of all the pre-treated and control samples ranged from (6.71%-6.43%). After 21 days of storage period, the maximum mean rehydration ratio was recorded in T_1 (6.76%) followed by T_2 (6.58%) while minimum was recorded in T_0 (6.42%) followed by T_3 (6.49%).

Mean rehydration ratio of cabinet dried cauliflower samples of control and all pre-treatments also showed a decreasing trend from (7.51%-7.30%) throughout the storage period. Maximum mean value rehydration ratio was obtained for T_1 (7.51%) followed by T_2 (7.39%) while minimum mean value of rehydration was obtained for T_3 (7.33%) followed by control T_0 (7.34%). During the 21 days of storage 1.0% KMS (T_1) was found best followed by 1.0% $Cacl_2$ (T_2).

The low moisture content attained following rehydration ratio due to the loss of water during drying process with resultant increase in the concentration of dissolved substance in the tissue of vegetables.

This may lead to the irreversible damage to the texture and these textural changes cause the tissues to shrink. As a result, upon reconstitution they were not able to regain their initial moisture content, volume (or weight) and tenderness (Pervin *et al.,* 2008). Better quality and rehydration ratio of dehydrated cauliflower was observed from 1.0% sodium metabisulphite and sodium sulphate treatment by Srivastava and Sulebele (1975).

Effect of various pre-treatments and different drying methods on browning (optical density) of cauliflower

The data pertaining to non-enzymatic browning in terms of optical density at 440 nm in sun dried and cabinet dried cauliflower samples with different pre-treatments are presented in Table 4.

It is depicted that minimum browning was noticed in cabinet dried samples with overall mean of (0.058%) and maximum browning was noticed in sun dried samples with overall mean of (0.0856%).

Statistical analysis revealed that effect of all the pre-treatments on non- enzymatic browning of sun dried samples was significant ($p<0.05$). Mean values of control and all the pre-treated sun dried samples showed significantly increased trend from (0.017%-0.194%) through the period of storage. Highest mean value (0.1657%) for non-enzymatic browning was noticed in T_0 treated sample while lowest value (0.0100) was noticed in T_1 treated samples. After 14^{th} day of storage there was a drastic increase in the mean non enzymatic browning of all the pre-treated as well as the control sample (0.099%-0.194%).

Data regarding the effect of pre-treatments on non-enzymatic browning of cabinet dried cauliflower samples was also significant ($p<0.05$). Cabinet dried samples showed less browning throughout the storage period as compared to sun dried samples. The mean values showed slight increasing trend which ranged from (0.013%-0.128%).

Highest mean non enzymatic browning was noticed in control (0.1235%) while lowest was noticed in T_1 (0.0066%) followed by T_2 (0.0429%). Browning in both dried cauliflower products during storage showed increased trend. Sharma *et al.,* (2000) found similar results during storage of dehydrated carrots. It was observed that the cabinet dried samples showed less browning compared to sun drying. Almost similar results were study by Kadam *et al.* (1988) while working in the drying of cauliflower.

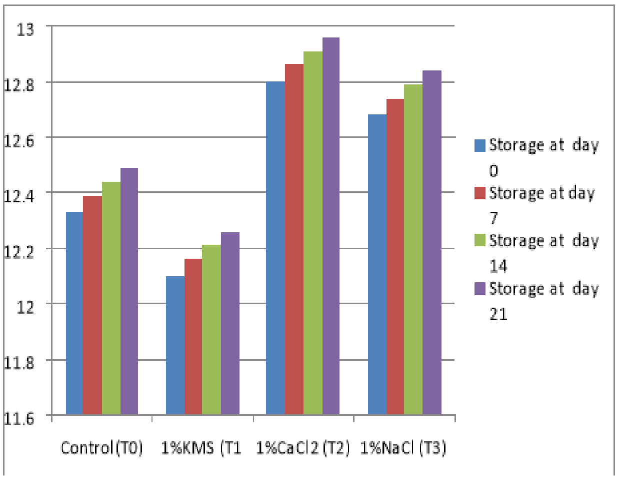
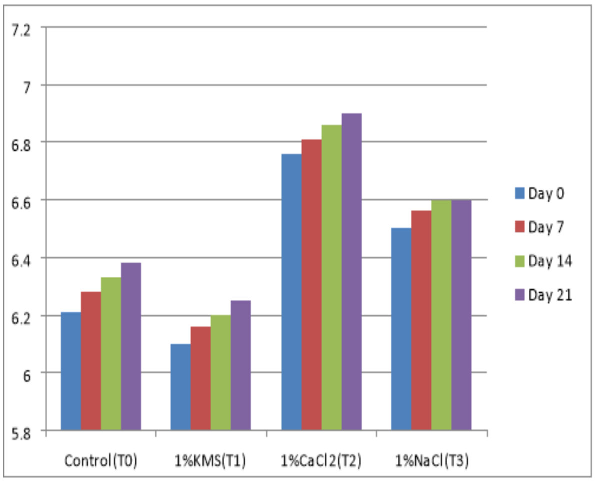


Fig. 1 : Effect of various pre-treatments on moisture



content of sun dried cauliflower during storage

Fig. 2: Effect of various pre-treatments on moisture content of tray dried cauliflower during storage

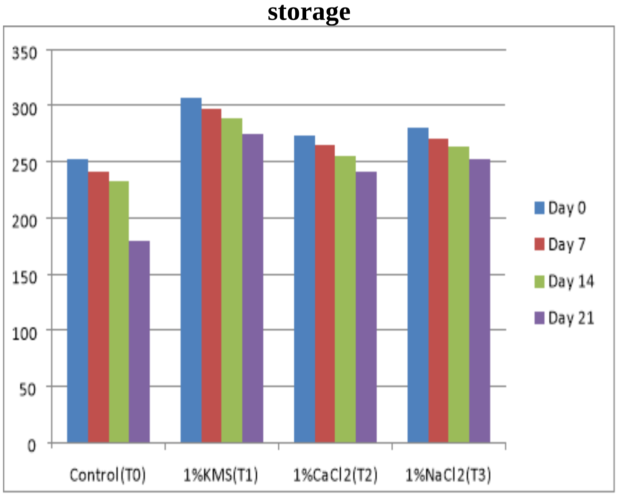


Fig. 3: Effect of various pre-treatments on ascorbic acid content of sun dried cauliflower during storage

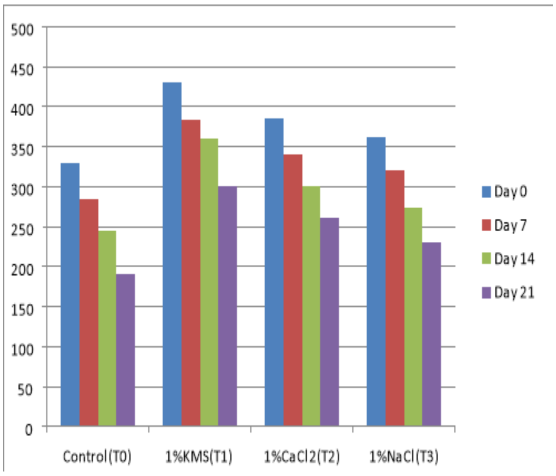


Fig. 4: Effect of various pre-treatments on ascorbic acid content of tray dried cauliflower during storage

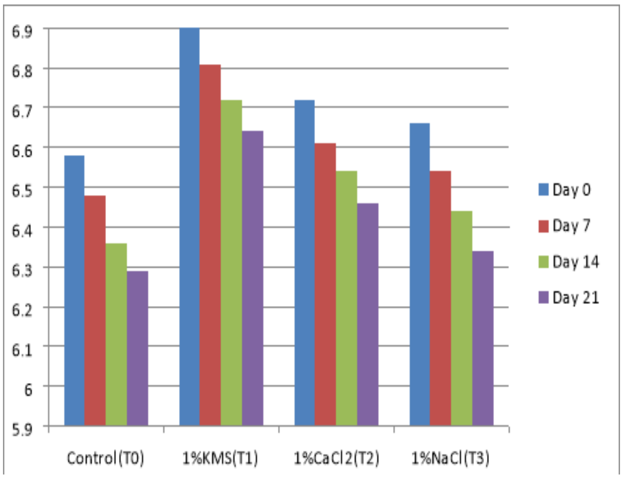


Fig. 5: Effect of various pre-treatments on rehydration ratio of sun dried cauliflower during storage

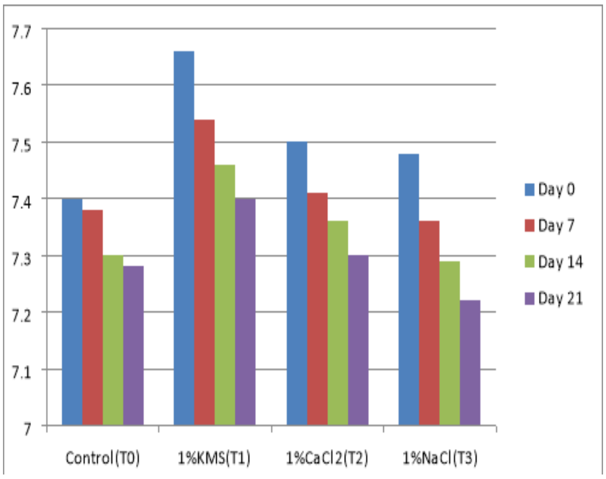


Fig. 6: Effect of various pre-treatments on rehydration ratio of tray dried cauliflower during storage

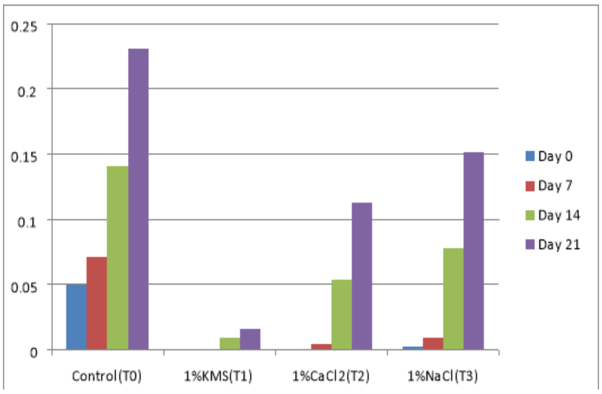


Fig. 7: Effect of various pre-treatments on enzymatic browning of sun dried cauliflower during storage

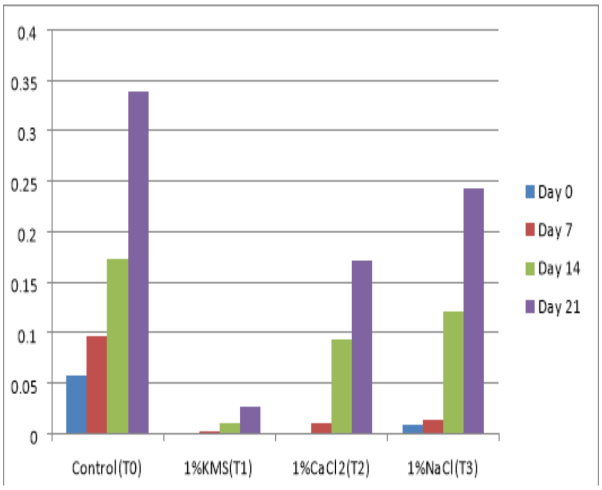


Fig. 8: Effect of various pre-treatments on enzymatic browning of cabinet dried cauliflower during storage

4. CONCLUSIONS

The most serious constraint for shelf-life enhancement is the activity of microorganisms. Drying or dehydration of fresh fruits and vegetables is one of the most energy intensive processes in the food industry.

For long term storage of dried vegetables sulphuring or using sulphite dip are the best pre-treatments.The dehydrated cauliflower treated with 1.0% KMS ranked first followed by 1.0% $CaCl_2$ and 1.0% NaCl. Drying of samples in cabinet drier proves to be most effective.

5. CONFLICT OF INTEREST

The authors don't have any conflict of interest.

6. ACKNOWLEDGMENTS

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T_0 = control sample

T_1 = KMS treated sample

T_2 = $CaCl_2$ treated sample

T_3 = NaCl treated sample

Fig. 9: Sun dried cauliflower samples with different pre-treatments

T_0 = control sample

T_1 = KMS treated sample

T_2 = $CaCl_2$ treated sample

T_3 = NaCl treated sample

Fig. 10: Cabinet tray dried cauliflower samples with different pre-treatments

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