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Effect Of Pre-Drying Treatments On Quality Characteristics Of Dehydrated Tomato Powder

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Abstract

Dehydrated Tomato Powder was prepared by drying fresh and healthy tomato. Before drying sample of tomatoes were subjected to different pre-treatments such as calcium chloride ($CaCl_2$), potassium metabisulphite (KMS), calcium chloride and potassium metabisulphite ($CaCl_2$ + KMS) and sodium chloride (NaCL). Untreated samples served as control. After pre-treatments, tomatoes were subjected to cutting and slicing. Then, solar dryer and tray dryer were used for dehydration. Drying process was done at temperature of 37 ^{0}C and 60-70 ^{0}C. At the bone dry condition samples were grinded in grinder, after grinding all samples were packaged in HDPE. Quality characteristics of tomato powder viz. moisture content, titratable acidity, lycopene content, dehydration ratio, rehydration ratio and non-enzymatic browning (NEB) as affected by dehydration process were studied. Storage study was also carried out for a period of 2 months for tomato powder packed into HDPE packaging materials. Change in lycopene content and NEB were estimated during storage at room temperature. Pre-treated samples for tray dryer in HDPE bag was selected as the best dehydration process

Keywords: *Pre-drying treatments; Solar drying; Tray drying, Tomato powder*

1. Introduction

Preservation of fruits, vegetables, and food are essential for keeping them for a long time without further deterioration in the quality of the product. Several process technologies have been employed on an industrial scale to preserve food products; the major ones are canning, freezing, and dehydration. Among these, drying is especially suited for developing countries with poorly established low-temperature and thermal processing facilities. It offers a highly effective and practical means of preservation to reduce postharvest losses and offset the shortages in supply.

Drying is a simple process of moisture removal from a product in order to reach the desired moisture content and is an energy intensive operation. The prime objective of drying apart from extended storage life can also be quality enhancement, ease of handling, further processing and sanitation and is probably the oldest method of food preservation practiced by humankind. Drying involves the application of heat to vaporize moisture and some means of removing water vapor after its separation from the food products. It is thus a combined and simultaneous heat and mass transfer operation for which energy must be supplied. The removal of moisture prevents the growth and reproduction of microorganisms like bacteria, yeasts and molds causing decay and minimizes many of the moisture-mediated deteriorative reactions. It brings about substantial reduction in weight and volume, minimizing packing, storage, and transportation costs and enables storability of the product under ambient temperatures.

India is one of the largest producers of the fruits and vegetables in the world. Tomato is third vegetable next to potato and sweet potato in consumption. Its processed from includes pulp, puree, paste, sauce, juice and peeled whole tomato .Tomato is popular vegetable fruit because its supplies vitamin c and variety of color and flavor to the food. Tomatoes are low in calories but proportionately high in sugar. Tomato as other vegetables can be dried using various methods. In any tomato drying technique, the required time for drying the product depends in many parameters such as tomato variety, the soluble solid (^{0}brix) of the fresh product, the air humidity, the size of the tomato segment, the air temperature, velocity and the efficiency of the drying system. The rate of drying depends on the end quality of the drying product. As the production of tomato in India is very high and increases day by day. Tomato has a limited shelf life at ambient conditions and is highly perishable. It creates glut production season and becomes scanty during off season. Short shelf life coupled with adequate processing facilities results in heavy revenue loss to the country. The demand for dehydrated tomato is increasing rapidly both in domestic and international market with major portion of being used for preparation of convenience food. Thus, there exists a need to develop suitable technology there exist a need to develop suitable technology for processing preservation of this valuable produce in a way that will not only check losses but also generate revenue for the country.

The objective of the present investigation were:(a) to determine the influence of different type of driers and dehydration conditions on physicochemical properties of tomato powder; and (b) to study the lycopene retention and browning reaction as affected by HDPE packaging material, pre-drying treatments and drying methods after storage.

2. Materials and Methods

2.1 Source of material and sample preparation

Fresh, dark red colored, good quality tomato was procured from the local market on daily basis prior to each set of experiments. Care was taken to select fresh and healthy raw materials without any defect on visual inspection. Tomatoes were washed with water to remove dirt and soil; further tomatoes were cut into uniform slices with knife.

2.2 Pre-Treatments given prior to dehydration process

The Tomato slices were treated as follows: a) Dipping in 1 g/100g $CaCl_2$ in water solution (1:1 w/w) at room temperature for 10 min. b) Dipping in Potassium Metabisulphite (KMS) 0.2 g/100g solution (1:1) at room temperature for 10 min. c) Dipping in 1 g/100g $CaCl_2$ in combination with 0.2 g/100g KMS in an equal mass of water for 10 min. d) Dipping in 7 g/100g NaCl at 80°C for 5 min in an equal mass of solution. The salt concentration and temperature were standardized in preliminary studies. Best combination was selected based on minimum salt absorption and maximum moisture removal. e) Tomato slices dipped in an equal mass of plain water for 10 min at room temperature were considered as control sample.

2.3 Chemical analysis

Moisture content was estimated as described by Rangana (1977). Ascorbic acid was determined by Rangana (1986). The color of non-enzymatic reaction was read at 420 nm.

2.4 Estimation of lycopene by Spectrophotometric method

The lycopene content was determined by spectrophotometer method based on that of Barrat and Anthon (2000). In this method acetone, petroleum ether and anhydrous sodium sulphate reagents were used. Took 5 g of sample and crushed repeatedly in acetone in pestle and mortar until the residue is colorless. Transferred the acetone extracts to a separator funnel containing 10 to 15 ml of petroleum ether. Mixed gently to take up the pigments into the petroleum ether phase . Transferred the lower (acetone) phase to a 100 ml volumetric flask and extracted it repeatedly with petroleum ether until colorless. Combined the petroleum ether extracts and dried over a small quantity of anhydrous sodium sulphate. Filtered the solution and made up the 100 ml with petroleum ether and measure the optical density at 503 nm using petroleum is blank.

Lycopene content was measured for 100 g of tomato fruit by using the following formula-
Lycopene (mg/100g) = 31.206 * O.D of sample
Where,
O.D. = Optical density

2.5 Dehydration processes

Pre treated tomato slices were drained thoroughly after dip treatments and used for dehydration using two different dehydration techniques. Solar and tray dryers were used for dehydration. The solar equipment was kept in open place exposed to the sunlight for drying process. Treated tomatoes were loaded into trays and dehydration experiments were carried out under direct sunlight during January-February with average sunlight of 7-8 h per day. But in case of tray dryer, dehydration experiments were carried out in hot air oven at 60-70^{0}C.

2.6 Physicochemical analysis

2.6.1 Dehydration Ratio
Dehydration ratio was calculated by taking the weights of sample before drying and the weight of sample after drying (Singh and Mohan Kumar, 2007).

$$\text{Dehydration ratio} = \frac{\text{Weight of sample before drying}}{\text{Weight of sample after drying}}$$

2.6.2 Rehydration Ratio
The rehydration test was conducted as recommended by McMinn and Magee (1997a) and Prabhanjan, Ramaswamay, and Raghavan (1995). Five grams sample of the dried tomato was added to 150 ml of distilled water in a beaker. The beaker was then placed on a hot plate and covered with a watch glass. The water was brought to boiling point, taking approximately 3 min, and then kept for 5 min. At the end of the rehydration period, the sample was transferred to a Buchner funnel, covered with No. 4 Whatman filter paper, and the excess water removed by applying a slight vacuum. The sample was then removed and weighed. The data was quantified in term of RR:
RR= Mrh

Mdh

Where Mrh is the mass of the rehydrated sample (kg) and Mdh the mass of the dried sample for rehydration test (kg).

2.6.3 Non-enzymatic browning (NEB)

For estimation of browning reaction, 5 g of the sample was mixed with 100 ml of 60 ml/100 ml absolute alcohol in a glass stoppered flask. The mixture was shaken thoroughly, kept for 12 h and then filtered through Whatman No. 4 fitter paper.

The absorbance (OD) of the filtrate was measured at 420nm against 60 ml/100 ml alcohol in a spectrophotometer. Browning index was expressed as absorbance value at 420 nm.

2.7 Storage study

Dehydrated tomato slices were powdered using grinder and packed into high density polyethylene-film (HDPE). Packages of 50 g of tomato powder were kept at room temperature ($35+2^0C$) for storage study. Samples were withdrawn after 0, 10, 20, 30 and 40 days to estimate the changes in lycopene degradation and also NEB value, during storage period.

3. Results and discussion

3.1. Effects of pre-treatments on the quality characteristics of dehydrated tomato powder

Effects of pre-treatments on quality characteristics of dehydrated tomato powder during dehydration in different driers are presented in table 1 and fig 1. From the table and figure it was evident that pre-treatment with $CaCl_2$ and NaCL increased water removal in tomato powder during drying and these pre-treatments influenced the drying kinetics of tomato by evident changes in texture of dips treated tomato. In comparison with these pre-treatments, control sample showed higher moisture content. Although there was no significant difference in moisture content of the dehydrated tomato powder of two different dryer but slight lower rate of moisture content of tomato powder which were pre-treated with NaCL, may be due to partial effect of osmotic dehydration, since pre-treatment was done at 80^0C for 5 min.

Similar observation reported by Gierschner, John & Philippos (1995 b).

Pre-treatment with $CaCl_2$+ KMS of both dryers with NaCL of solar and $CaCl_2$ of tray dryer showed slightly more acidity as compared to the control sample while tomato powder pre-treated with distilled water had lower acidity. Comparison of different drying methods indicated higher acidity in samples dried with tray dryer which is pre-treated with $CaCl_2$ may be related to the partial fermentation occurred or due to longer time consumption during dehydration process. Sample pre-treated with KMS had the least Vitamin C retention as compared with others pre-treatments. Good Vitamin C retention in KMS pre-treated samples was as a result of inactivation of the endogenous enzymes such as ascorbic acid oxidase, cytochrome oxidase and per-oxidase as reported in similar experiment by Okorie et al., (2004).

Dehydration ratio reported as, ratio of mass of tomato slices before loading into the drier to the mass of dehydrated products. Different pre-drying treatments used in this study could influence the dehydration ratio of the tomato slices. NaCl treated samples showed lowest dehydration ratio as compared to other treatments. Since NaCl treatment was done at higher temperature, great part of the juice leached to the osmotic medium. Total moisture content of tomato was partially decreased after pre-drying treatment. Treatment with calcium of cut tissue reduces its respiration and intensifies the repair process the firmness is either maintained or increased. Calcium appears to help maintain structural integrity of membranes and cell walls. Calcium binds to the cell wall and cross- lines, particularly with pectin components of the middle lamella. In view of the above discussion calcium pre-drying treated samples could maintain the better dehydration ratio as compared to the control in all the experiments and losses were less during dehydration process. Combination of calcium chloride and KMS in tray dryer could provide slight improvement in dehydration ratio. There was no significant difference regarding to dehydration ratio although tray dried sample showed slightly better ratio in comparison to those other dehydration methods.

If pre-drying treatment and drying itself would not induce any changes in the material rehydration could be treated as a process reversible of dehydration. In practice most of the changes are irreversible and rehydration cannot be considered simply as a process reversible to dehydration. Rehydration can be considered as a measure of the injury to the material caused by drying and treatment preceding dehydration. RR of dehydrated tomato powder was found to vary from 0.68 to 1.51, which was affected significantly by the pre-treatments. NaCL pre- treated tomato powder showed better rehydration property because it is believed that sodium and chloride ions permeate the tomato during soaking and re-associate as NaCL crystals on drying inside the cellular compartments. Tray dried tomato powder attained better rehydration ratio as compared to the solar dried samples, probably due to uniform exposure of slices to the drying air condition and better heat transfer, leading to less textural changes during dehydration which subsequently offered higher RR of the final product. Solar dryer could not maintain the constant rate of drying due to changes in air temperature, though drying carried out in low temperature. Slight shrinkage and hardening caused less reconstitution properties of the dehydrated samples.

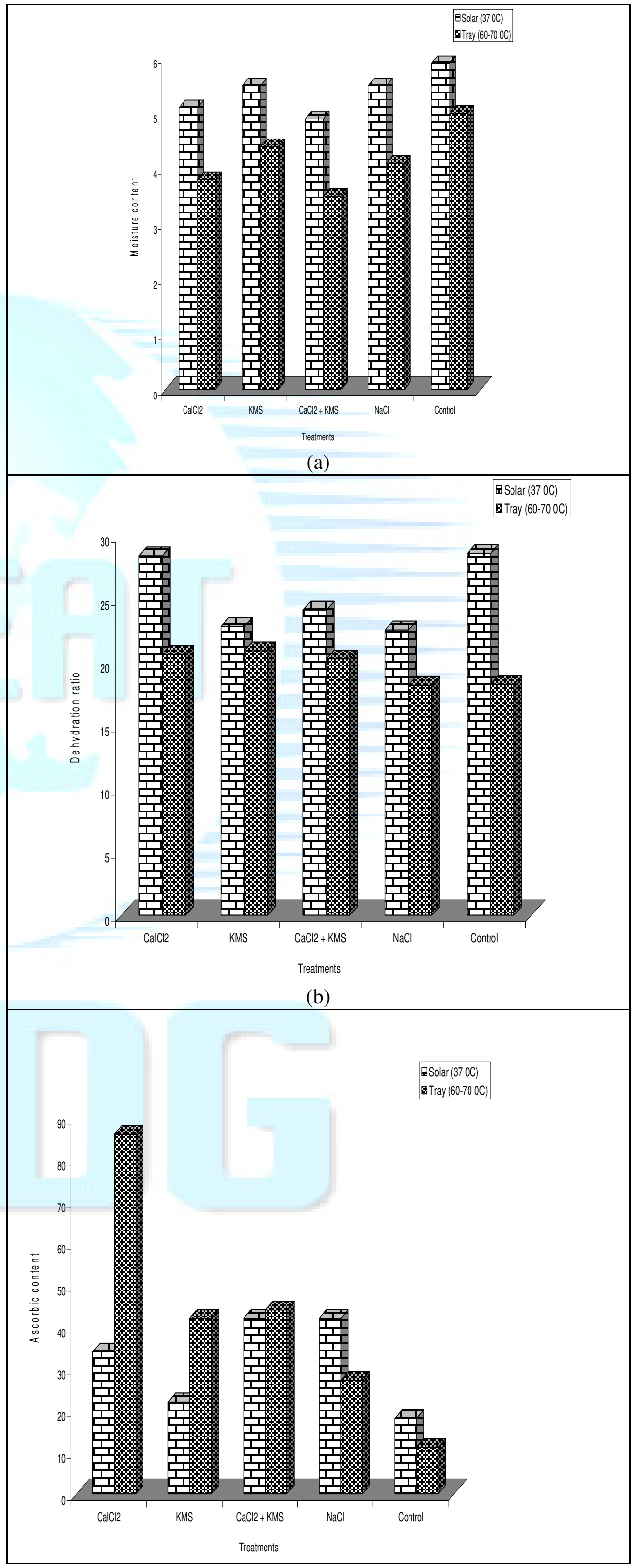
Table 1 Effect of different pre-drying treatments and drying methods on parameters of physico-chemical characteristics of tomato powder

Parameters	DM	Treatments				
		$CaCl_2$	KMS	$CaCl_2$+KMS	NaCL	Control
Moisture Content (%)	SD	5.1	5.5	4.9	5.5	5.9
	TD	3.8	4.4	3.5	4.1	5.0
Ascorbic Acid (Mg/100g)	SD	34	22	42	27.2	18
	TD	86	42	44	42	11.2
DR	SD	28.44	22.84	24.15	22.55	28.62
	TD	20.63	20.91	20.27	18.18	18.24
RR	SD	0.685	0.905	1.125	1.215	0.905
	TD	1.15	0.82	1.275	1.51	1.395
Lycopene Content	SD	93.68	97.26	93.52	96.95	101.85
	TD	76.45	86.25	78.45	83.85	99.85
NEB	SD	1.897	2.177	2.438	2.941	3.002
	TD	1.165	1.56	1.994	2.17	2.45

DM=drying methods, SD=solar dryer, TD=tray dryer, NEB= non-enzymatic browning, DR=dehydration ratio, RR=rehydration ratio

Because of importance of tomatoes to human health, lycopene (antioxidants) may be considered a valuable quality attribute of tomatoes and it is important to minimize losses of these compounds during post-harvest period. Fruit that are harvested at stages prior to full ripeness show an increase in lycopene content during post-harvest ripening. Tomatoes and tomato based sauces, juice and ketchup account for more than 85% of the dietary intake of lycopene for most people. The lycopene content of tomatoes depends on species and increases as fruit ripens. Raw tomato contains 8.8 µg/g (wet weight) while tomato juice and tomato ketchup contains 86-100 µg/g (wet weight) and 63-131 µg/g (wet weight). But results indicate that dehydration methods decreased lycopene retention in dehydrated tomato powder, but the rate of degradation was significantly different and pre-treatments influenced during dehydration process. KMS pre-treated had significant protective effective lycopene degradation and it was more effective when combination of $CaCl_2$+KMS was used in tray dryer. Slightly better color was observed in the samples treated with $CaCl_2$ and NaCl. Results regarding the effect of KMS were qualitatively similar to those reported by Sharma

Fig: 1 Effect of different pre-drying treatments and drying methods on parameters of physico-chemical characteristics of tomato powder



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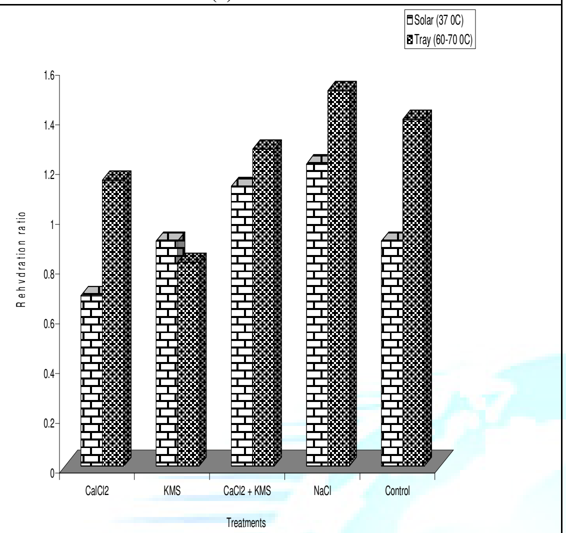

(d)

and Maguer (1996) and Baloch, Buckle, and Edwards (1987).Lycopene retention was observed less in tomato samples dried in tray drier as compared to the solar drier.

During dehydration and subsequent storage the typical red color of tomato gradually changes to brick-red and then brown. This phenomenon which is known as non-enzymatic browning (NEB) or Millard reaction produces dark pigments and destroys the natural color of products Heat damage and browning was observed in all of the pre-treated samples with significant variations in rate of reaction depending upon the treatment used before dehydration. CaCl2 showed independent significant effect to prevent or reduce the rate of browning followed by KMS, and where CaCl2 used along with KMS the NEB was recorded the least compared to other treatments and the best results were obtained while using the two chemicals in combination form. Control sample showed maximum rate of darkening and browning in all the experiments. Potassium metabisulphite is used to protect the carotenoid pigments and color retention in dehydration and its effect is more known during processing but a definite explanation of the mechanism whereby calcium serve to retard non-enzymatic browning in dehydration of tomato cannot be offered clearly. It has been reported that calcium may be acting in some manner to block the amino group, whereby the latter is restrained from entering into the browning reaction. It is also believed that calcium is capable of forming chelating compounds with organic substances having an alpha amino carboxylic acid structure. Under these circumstances, it would be reasonable to expect that calcium treatment may be applicable to control non-enzymatic browning in many products where this particular type of browning reaction maybe a problem. (Baloch & Khan, 1997; Simon, Wagner, Silveria, & Hendel, 1955) Browning index, which is an indicator of the extent of browning, was higher in solar dried samples than tray dried. Direct exposure of thin slices of tomato for longer time of dehydration may be considered as reason of these changes.

Results related to quality of solar dried sample are in agreement with reported value of Suguna, Usha, Screenarayanan, Raghupathy & Gotthandapani on dehydration of mushroom.

3.2 Storage study

In general, dehydrated and powdered tomatoes have poor lycopene stability unless carefully processed and promptly placed in sealed packages and kept in proper storage conditions. The main causes of tomato lycopene degradation during processing and storage are isomerization and oxidation. Lycopene content in dehydrated tomato powder was influenced by drying methods, pre-drying treatments and storage condition including packaging material during storage period. All samples showed a progressive loss of lycopene throughout the storage period, with a different rate of degradation and color changes. Results obtained from analysis of lycopene for stored tomato powder in different packaging material are presented in 2. It can be seen that all the pre-treatments have shown a good effect on lycopene retention as compared to the control sample. But results indicate that dehydration methods decreased lycopene retention in dehydrated tomato powder during storage. The main cause of tomato lycopene degradation during processing and storage are isomerization and oxidation (Shri & Maguer, 2000). Lycopene content in dehydrated tomato powder was influenced by drying methods, pre-drying treatments and storage condition including packaging material during storage period. All samples showed a progressive loss of lycopene throughout storage period with a different rate of degradation. The results obtained from analysis of lycopene of different pre-treated sample of tomato powder of different two dryers and stored in HDPE packaging material was tabulated in table 2. Combination of $CaCl_2$ with KMS had the best result, especially in the first month of storage. Result also showed that KMS and $CaCl_2$ alone could delay significantly changes in lycopene degradation during storage. $CaCl_2$ and NaCL pre-treatment had slight effect on lycopene retention but comparatively higher than control samples. Lycopene retention was observed less in tomato samples dried in tray drier as compared to the solar drier.

Table 2 Effect of storage period (days) on changes in lycopene content of dehydrated tomato powder from solar and tray dryer

Treatment	PM*	DM	Storage period (days) 0	10	20	30	40
$CaCl_2$	HDPE	SD	93.68	91.77	76.08	67.93	59.19
		TD	76.45	67.71	62.22	48.68	36.35
KMS	HDPE	SD	97.26	92.58	79.2	64.31	52.95
		TD	86.25	72.58	63.72	51.61	42.28
$CaCl_2$+KMS	HDPE	SD	93.52	88.9	81.85	63.37	61.72
		TD	78.4	75.73	62.31	52.95	37.57
NaCL	HDPE	SD	96.95	92.18	71.99	62.53	59.19
		TD	83.85	69.53	62.53	56.82	38.49
Control	HDPE	SD	101.85	94.14	88.12	75.67	61.63
		TD	99.85	93.61	66.56	60.53	48.8

*PM= packaging material

Browning is as a result of chemical process and is a function of the temperature, the structure of the material and residence time during processing as well as storage period and it may directly affect the sensory and nutritional quality of the dehydrated products. Results of studies on changes in non enzymatic browning for tomato powders, which were packed and stored in room condition, are presented in Tables 3. The effects of pre-treatment and packaging on the browning index of tomato powders were very evident during storage. Results showed that control sample had the maximum rate of darkening and browning in all experiments. The effectiveness of $CaCl_2$ was increasing the resistance of tomato powder due to non-enzymatic discoloration. $CaCl_2$ used in conjunction with KMS was shown to be more effective than either of the two used individually and provide extension of shelf life in acceptable condition of storage period. Table 2 shows changes in NEB for tomato powders obtained by solar dryer, during storage period. The effect of pre-treatments on samples showed higher rate of increase in browning specially after one month of storage. Samples from tray dryer had less NEB and significant changes were observed after approximately 2 months (or 50 days) of storage period in case of control and KMS pre-treatments.

Table Effect of storage period (days) on changes in NEB of dehydrated tomato powder from solar and tray dryer

Treatment	PM*	DM	Storage period (days) 0	10	20	30	40
$CaCl_2$	HDPE	SD	1.89	2.177	2.438	2.941	3.002
		TD	1.165	1.56	1.994	2.17	2.45
KMS	HDPE	SD	1.697	2.061	2.538	2.967	3.117
		TD	1.355	1.654	2.042	2.32	2.764
$CaCl_2$+KMS	HDPE	SD	1.978	2.031	2.623	2.849	2.997
		TD	1.204	1.697	1.997	2.427	2.514
NaCL	HDPE	SD	1.897	2.004	2.307	2.954	3.107
		TD	1.232	1.821	2.004	2.229	2.687
Control	HDPE	SD	1.975	2.425	2.824	3.017	3.564
		TD	1.564	1.94	2.133	3	3.2

*PM= packaging material

4. Conclusions

Dehydration were carried out for tomato slices, pretreated with four different treatments, i.e. CaCl2, KMS, CaCl2 +KMS, NaCL and Control using different dehydration methods. The dehydrated tomato slices were made into powder and storage study was carried out for number of days using HDPE packaging material. Among the two different driers used in this experiment, tray dried samples attained better quality characteristic as compared to solar dried samples. KMS treated of both dryer was found to have more protective effect on quality of dehydrated products during dehydration process. Storage studies carried out for period of almost 2 months showed highly effectiveness of treatments during storage. While control samples were slightly dark brown with degradation and loss of lycopene content during storage. Regarding effect of $CaCl_2$ for browning and protective effect of KMS on lycopene was observed in stored tomato powder. Combination of these two treatments presented highly acceptable tomato powder with red color even after these storage periods. HDPE was found to be a good packaging material to maintain the quality of tomato powder with respect to lycopene degradation and browning reactions. Tomato powder was safe for consumption up to 2 months at ambient storage temperature, where it was packed in HDPE bag

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