



## Effects of Pre-drying Chemical Treatments on Quality of Cabinet Dried Tomato Powder

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### Abstract

The focus of this research was to analyze the yield, physico-chemical and nutritional quality of a cabinet dried tomato powder as affected by three (3) chemical treatments (KMS, CaCl<sub>2</sub> and both). Dehydration process was carried out using a cabinet dryer at a constant air flow velocity of 0.7 m/s and air temperature in the range of 60-65°C based on preliminary tests by dipping in 0.2% (w/w) potassium metabisulphite (T<sub>1</sub>) and 1% (w/w) calcium chloride (T<sub>2</sub>) independently and 1% (w/w) calcium chloride (CaCl<sub>2</sub>) along with 0.2% (w/w) potassium metabisulphite (KMS) in water solution (T<sub>3</sub>) for 10 minutes. The effect of 3 pre-drying treatments on quality of cabinet dried tomato powder was analyzed by determining moisture content, rehydration ratio, total sugar, total acidity, fat, protein, ash, crude fiber, pH, total carotenoids, vitamin-C, minerals (calcium, iron, phosphorus) and sensory analysis. The results expressed that the treatment T<sub>3</sub> achieved the highest yield of tomato powder (4.6 g/100 g). The control sample showed highest moisture content (6.9 g/100 g) and dipping in 1% CaCl<sub>2</sub> along with 0.2% KMS presented the lowest moisture content (5.9 g/100 g). Sample T<sub>3</sub> showed highest total sugar content (49.1 g/100 g). The study also depicted that the total carotenoids content in tomato powder was 0.21 mg/100 g which was lower than that of fresh tomato (2.1 mg/100 g). Micronutrients such as vitamin-C, Calcium, phosphorus and iron were found to be 35.30 mg/100 g, 336.72 mg/100 g, 105 mg/100 g and 12.23 mg/100 g, respectively in case for T<sub>3</sub> sample. Sensory analysis (color, texture, flavor and overall acceptability) of tomato powder was carried out by trained and untrained panelists and their interpretation was done by using statistical ANOVA Test. There was no significant difference between control and treated samples regarding to their texture, flavor and overall acceptability but significant difference was observed in case of color.

**Keywords:** ANOVA, Cabinet drying, KMS, Pre-treatment, Tomato powder

### Introduction

Tomato (*Lycopersicon esculantum* L.) belongs to the family of *Solanaceae*, and is one of the most widely consumed fresh vegetables in the world. Tomatoes are rich source of lycopene (60-90 mg/kg), polyphenols (10-50 mg/kg) and small quantities of vitamin E (5-20 mg/kg) and also a nutritionally recognized vegetable for their vitamin C content, with an average tomato supplying about 40% of the adult United States Recommended Daily Allowances (RDA) of 60 mg (Charanjeet *et al.*, 2004). There is a rapid development of tomato processing industries in recent decades with a series of interlinked activities such as production of salad, soup, juice, puree, paste and powder and extraction of oil from the pulp and the demand for dehydrated tomato is increasing rapidly both in domestic and in international market with major portion of it being used for preparation of convenience food since it has limited shelf life and highly perishable at ambient conditions (Purseglowe *et al.*, 2001). Moreover, in 2001 the US produced 11.6 million metric tons of processing tomatoes, worth \$ 913 million and Brazil produces more than 3.7 million tons of tomato annually, with total farm to

table losses of up to 40% (Lewicki *et al.*, 2002; Latapi and Barrett, 2006) and in Bangladesh tomato was grown in 44,275 acres of land with the production of approximately 190,213 metric ton in 2009-2010 (BBS, 2010).

Presently, fresh tomato products are being processed and marketed in Bangladesh in the form of puree, paste, catch-up, sauce, pickles, chutney (Sharfuddin and Siddique, 2000) etc but interest in the production of dehydrated tomato product in all over the world is increasing due to the possibility of using them in pizza toppings, snacks and other savoury dishes (Gisele *et al.*, 2004; Lewicki *et al.*, 2002).

Processing of tomatoes using sun drying with cut pieces, drying of whole tomatoes, spray drying and convection drying using solar or mechanical systems has been used for many years (Baloch *et al.*, 1997; Collins *et al.*, 1997; Hawlader *et al.*, 1991; Olorunda, *et al.*, 1990; Shi *et al.*, 1999; Zaroni *et al.*, 1999). Traditional sun-drying is a slow process compared with other drying methods and quality losses may result from high moisture content, color degradation by browning, microbial growth (Okos *et al.*, 1992;

Lewicki *et al.*, 2002). Sun drying requires 7 to 12 days, and results in a product with typically 12% to 24% moisture and robust taste. Sun-dried tomatoes darken during storage, which is typically 9 to 12 months (Ecom, 1997). Scientific literature on methods for improving the quality of dehydrated tomatoes through modification of the traditional process or incorporation of pretreatments is limited and variable. Therefore, there has been a rapid stimulation to search for new alternatives that comprises of manipulation and addition of chemical preservatives/additives more specifically pre-treated with pre-drying chemicals (Latapi and Barrett, 2006)

Pre-treatments with chemicals before drying have been used in order to minimize adverse changes during drying and subsequent storage tomatoes. The most common and least expensive method to prevent enzymatic browning in fresh prepared vegetables or tomatoes is by the use of sulphiting or salt agents such as metabisulphite and or calcium chloride since they have multiple functions (Roy and Choudary, 1972). Traditionally, tomatoes are dehydrated after a pretreatment with sulfur dioxide, in closed chambers either by burning sulfur or gassing with sulfur from a cylinder (Valley Sun, 2000). Another method for introducing of sulfur dioxide into the tomato is by dipping in sodium metabisulfite solutions (Pazyr *et al.*, 1996).

Presently, there are few published studies comparing the single or mixed effects of calcium chloride and sodium metabisulfite dipping treatments on quality parameters of cabinet-dried tomatoes. Hence, the objective of this study was to evaluate the effects of 3 pretreatments on various qualities of cabinet dried tomatoes including: total sugar, acidity, fat, protein, ash, crude fiber, pH, total carotenoids, vitamin-C, minerals (calcium, iron, phosphorus) and sensory analysis and to determine the influence of cabinet driers on pretreated dehydrated powder.

## **Materials and Methods**

### ***Experimental location and time***

The study was conducted in the laboratory of the Department of Food Processing and Preservation

under the Faculty of Agro-Industrial and Food Process Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur in collaboration with laboratory of Food Enzymology Section, Vegetable Technology Section, Fruit Technology Section and Applied Nutrition Section under the Institute of Food Science and Technology of Bangladesh Council of Science and Industrial Research, Dhaka during the year of 2011.

### ***Materials***

#### ***Chemicals and raw materials***

The chemicals such as sodium hydroxide (NaOH), sodium chloride (NaCl), hydrochloric acid (HCl), petroleum ether, copper sulphate (CuSO<sub>4</sub>.5H<sub>2</sub>O), ammonium sulphate, boric acid used in this research work were obtained from E. Merck (West Germany) and Nitric acid (HNO<sub>3</sub>) Sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) were obtained from British Drug House (England). The tomatoes of var. hybrid were collected from the harvesting field located at Gabura in Dinajpur district during the period of April, 2011. The collected tomatoes were fresh, ripe, fully matured and 60-75 mm in average diameter and with an average weight of 90-110 gm. After collection, they were stored at room temperature (25±2<sup>o</sup>C) and then sorted and washed with distilled water to remove dirt and soil; further tomatoes were cut into slices (from stem scar to blossom end) with thickness of 5 mm by using a stainless steel knife.

### ***Methods***

#### ***Pre-treatments with chemical (KMS and CaCl) before dehydration process***

The Tomato slices were pre-treated by dipping in 3 different chemical solutions according to the method as followed by Ghavidel and Davoodi (2010) as presented in Table 1 and Figure 1 as follows: a) Dipping 1 gm/ 100 gm of CaCl<sub>2</sub> in water solution (1:1 w/w) at room temperature for 10 minutes. b) Dipping KMS 0.2 gm/ 100 gm solution at room temperature for 10 minutes. c) Dipping in 1 gm/ 100gm CaCl<sub>2</sub> in combination with 0.2 gm/ 100 gm KMS in an equal mass of water for 10 minutes. d) Tomatoes slices dipped in an equal an equal mass of plain water for 10 minutes at room temperature were considered as controlled sample Ghavidel and Davoodi (2010).

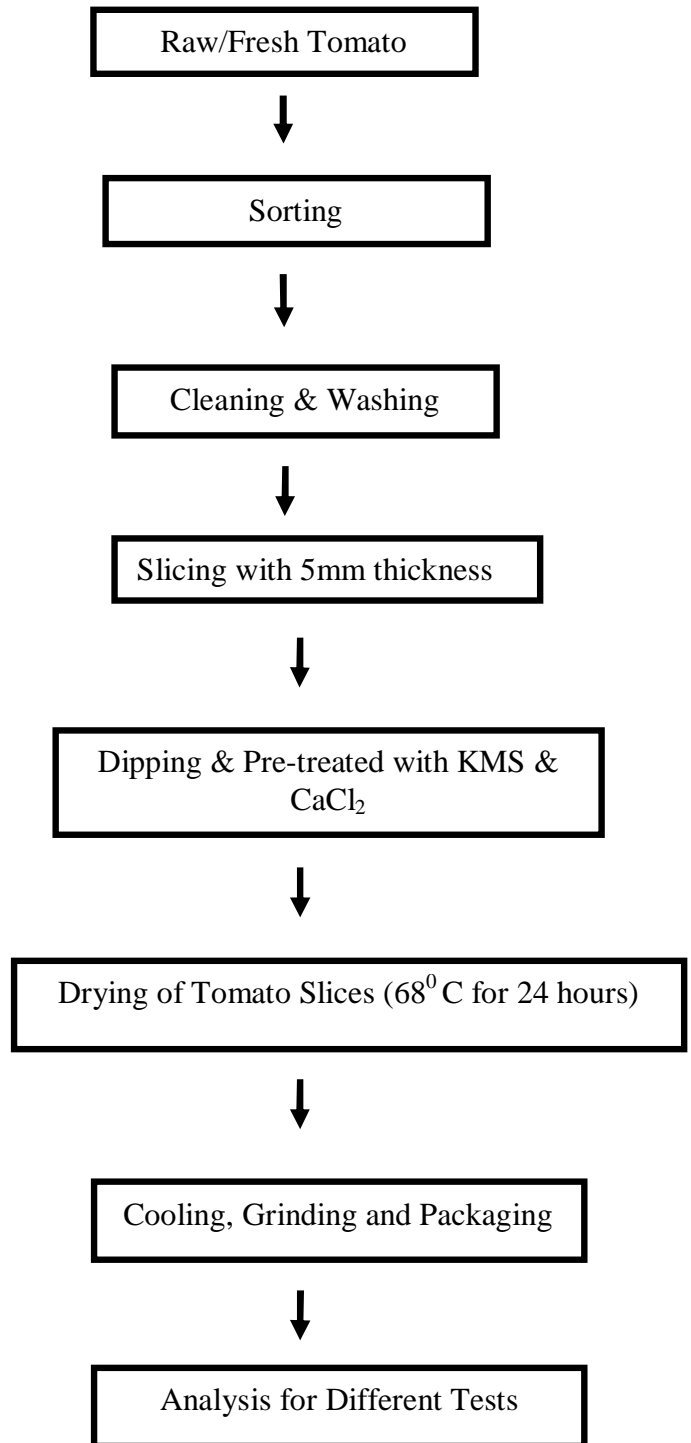


Fig. 1. Process flow chart of tomato dehydration process

**Table 1.** Experimental design for studies on effects of chemical pre-drying treatments on cabinet dried tomato powder

Treatment	Concentration of Pre-drying treatments	Studied parameters
T <sub>1</sub>	0.2% KMS (1:1 w/w)	Moisture, rehydration ratio/capacity, drying curves, physico-chemicals and shelf life and sensory analysis
T <sub>2</sub>	1% CaCl <sub>2</sub> (1:1 w/w)	
T <sub>3</sub>	0.2% KMS+1% CaCl <sub>2</sub> (1:1 w/w)	
T <sub>0</sub>	Control in plain water	

\*Dipping time was 10 min.

\*1000 g fresh tomato was used

**Table 2.** Effect of pre-treatments on cabinet drying efficiency

Treatment	Concentration of Pre-drying treatments	Tomato Powder (gm)	Dry matter <sup>a</sup> (%)	Water loss <sup>a</sup> (%)
T <sub>1</sub>	0.2% KMS (1:1 w/w)	38.27	3.83	96.17
T <sub>2</sub>	1% CaCl <sub>2</sub> (1:1 w/w)	46.1	4.60	95.40
T <sub>3</sub>	0.2% KMS + 1% CaCl <sub>2</sub> (1:1 w/w)	43.6	4.36	95.64
T <sub>0</sub>	Control in plain water	40.9	4.09	95.91

<sup>a</sup>All means are based on triplicate values

**Dehydration process using cabinet dryer: preparation of tomato powder**

The pre-treated tomato slices were used for dehydration using air convection drying techniques as described by Narsing Rao *et al.* (2008). The pretreated tomato slices were dried in the cabinet drier (Figure 1). A cabinet dryer (136-120, Seoul, Korea) was used for the dehydration experiments. The tomatoes were placed uniformly on stainless steel trays by spreading the slices at an area interval of 1.25 lb/ft square as a single layer (loading density) and experiments were conducted at 60-65°C air temperatures and at a constant airflow velocity of 0.7 ms<sup>-1</sup> for 24±2 hours. In each experiment, about 10 kg of tomato slices in each tray were dried. Weight losses (thus moisture content) of sample during drying process was determined by gravimetric method after each 4 hours interval and continued until no further weight changes were observed. After cooling at room temperature, the dried tomato flakes were ground by using blender to produce tomato powder. The tomato powder was then packaged in low density polyethylene bags (LDPE) for further investigation or analytical research.

**Quality characteristics of dehydrated tomato dehydration ratio (DR)**

Dehydration ratio was calculated as mass of sliced tomato before loading to the drier to mass of dehydrated material at the time of removal from drier (Sebii *et al.*, 2002).

**Rehydration ratio (RR)**

The rehydration test was carried out as followed (Lewicki, 1998; Levi *et al.*, 1988). Two grams (2g) of tomato powder was weighed (initial weight) into 250 ml beakers and submerged in 50 ml distilled water at room temperature for 0.5, 1.0, 1.5, 2.0 etc hours and the samples were drained by vacuum pump until all the water was drained out and the

adhered water was absorbed by tissue paper and finally weight of rehydrated sample was taken (final weight). The rehydration ratio was obtained by dividing the rehydrated weight by the initial weight.

**Determination of P<sup>H</sup>**

The pH of the selected samples was determined by a pH meter (Hanna instruments- ORPP), salinity-sodium tester (ISO-9001 certified company; Woonsocket, RI 02895) with the supplied pH 4.0 buffer solution, distilled water and 50 ml beakers.

**Estimation of proximate compositions**

Proximate analysis of dehydrated tomato powder for moisture, ash, crude fat (solvent extraction), crude protein (Kjeldahl N × 6.25), and crude fiber were determined in at least triplicate using the methods as described by AOAC (AOAC, 1984).

**Estimation of moisture content**

The moisture content was determined according to the AOAC (1984) method. Five (5) g of samples was accurately weighed into dried crucible and placed in an oven (Mettler Toledo, AB 104) at 105±2°C for 4 (four) hours. After drying, the samples were removed from the oven and placed in desiccators to cool for about 30 minutes and then reweighed. The process of evaporation, cooling and weighing process were repeated until constant weight was found.

**Table 3.** Quality Parameters of Dehydrated Tomato by different chemical and physical analysis

Treatment*	Proximate composition (g/100 g of dried sample)							Minerals (mg/100g of dried sample)			Total Carotenoids (µg/100g)	Dehydration Ratio (DR)	Acidity (g/100g)	pH
	Moisture	Total sugar	Fat	Protein	Ash	Crude fiber	Vitamin-C	Ca	Fe	P				
T <sub>1</sub>	6.1	48.7	2.8	13.1	10.21	6.1	ND	ND	ND	ND	ND	15.03	5.86	4.21
T <sub>2</sub>	6.5	48.1	2.8	12.6	10.36	6.3	ND	ND	ND	ND	ND	14.67	6.28	4.40
T <sub>3</sub>	5.9	49.1	3.0	13.9	10.72	6.5	35.30	336.672	12.23	105	210	14.38	6.05	4.25
T <sub>0</sub>	6.9	47.9	2.2	13.1	10.25	5.9	ND	ND	ND	ND	ND	15.50	6.12	4.20

\*All means are based on triplicate value

\*\*ND: Not determined

**Table 4.** Mean sensory scores of tomato powder

Sensory attributes	Sample (T <sub>1</sub> )	Sample (T <sub>2</sub> )	Sample (T <sub>3</sub> )	Sample (T <sub>0</sub> )	LSD
Colour	7.063 <sup>ab</sup>	6.813 <sup>b</sup>	7.93 <sup>a</sup>	5.563 <sup>c</sup>	1.626
Flavor	6.688 <sup>b</sup>	5.875 <sup>b</sup>	7.93 <sup>a</sup>	6.188 <sup>b</sup>	1.739
Texture	7.313 <sup>b</sup>	6.688 <sup>b</sup>	7.81 <sup>a</sup>	6.313 <sup>b</sup>	2.389
Overall acceptability	7.063 <sup>b</sup>	6.625 <sup>b</sup>	7.75 <sup>a</sup>	6.125 <sup>b</sup>	2.753

\*Means with same superscript within a color are not significantly different at P<0.05

\*Sample (T<sub>3</sub>) = Powder from 1% CaCl<sub>2</sub>+ 0.2 % KMS treated

\*Sample (T<sub>1</sub>) = Powder from 0.2% KMS treated

\*Sample (T<sub>2</sub>) = Powder from 1% CaCl<sub>2</sub> treated

\*Sample (T<sub>0</sub>) = wi

#### ***Estimation of total ash***

The ash was determined by the method as reported in the handbook of AOAC (1984). samples were weighed (5g) accurately in a previously cleaned and dried- weighed crucible. At first the crucible containing sample was placed in an oven (100-105<sup>0</sup>C) for 4 hrs to remove moisture. The moisture free sample was completely charred (free from carbon residues: appears in grayish-white) in a heating mantel followed by heating (ashing) in a muffle furnace at 600<sup>0</sup>C for 3 hours. Then it was removed from furnace and cooled in desiccators and weighed. To ensure complete ashing, the crucible was again heated in a muffle furnace for one hour. Then this was removed from the furnace and cooled in desiccators and weighed again.

#### ***Estimation of protein content***

200 mg of oven dried ground pulse sample was placed in a Mikrokjeldahl digestion flask. 500-600 mg of digestion mixture (catalyst) and 5ml of concentrated sulphuric acid were added into the flask. The flask was cautiously heated on a digestion rack for one hour until a greenish clear digest appeared. The clear digest was allowed to cool and then dissolved in minimum amount of distilled water (5-10 ml) and carefully transferred to a Mikrokjeldahl distillation set. To the digested sample in the apparatus, 20 ml of 40 percent NaOH solution was added through funnel stopcock. Distillation commenced immediately by closing the steam by-pass and opening the inlet stopcock on the steam jet arm of the distillation apparatus. The distillate was collected for 5 minutes in a 50 ml receiver flask containing 2 drops of mixed indicator and 20 ml boric acid till the color of the solution changes. The distillate was titrated against a standard HCl solution and the titrated volume (TV) was noted.

#### ***Estimation of crude fat (ether extract) content***

Five grams (5g) of previously ground and dried pulse sample was placed in a thimble plugged with cotton. The thimble with its contents was transferred to a Soxhlet extractor (Gerhardt) and extracted with ethyl ether for 16 hours. At the completion of the extraction, the ether or fat extract was transferred from the extraction flask into a pre-weighed conical flask with 4-6 times rinsing of ethyl ether. The ether was then removed by evaporation and the flask with the residue dried in an oven at 100<sup>0</sup>C for 30 minutes.

#### ***Estimation of crude fiber content***

Moisture and fat free sample (5g) was poured into a cleaned and oven dried 500 ml beaker containing 200 ml of pre- heated sulphuric acid (0.255N). The mixture was boiled for 30 minute keeping the volume

constant by the addition of distilled water at frequent interval. The mixture was then filtered through muslin cloth and the residue was washed several times with hot water until it was made acid free. The residue was then transferred into a 500ml clean and dry beaker containing 200 ml of pre-heated NaOH (.0313N) and boiled for 30 minutes. After boiling the mixture was filtered through a muslin cloth and the residue was washed several times with hot water followed by washing with alcohol and then ether until the sample was made alkali free. This alkali free sample was then dried in an oven at 105<sup>0</sup>C for four hours, cooled in a desiccator and weighed (a). Next this crucible was heated in a muffle furnace at 600<sup>0</sup>C for 3-4 hours, cooled and weighed again (b). This difference in the weights (a-b) represents the weight of crude fiber present in the sample.

#### ***Determination of total sugar***

Sugar content of tomato powder was determined according to Lane and Eyanon (1923). An amount of 25 ml of the standard invert solution was pipette into a 100 ml volumetric flask and about 50 ml of water was added. A few drops of phenolphthalein indicator was added and neutralized with 20% NaOH until the solution turned pink. Then acidity with 1N HCl was added drop wise until one drop caused the pink to mark with water (1 mL = 25mg of invert sugar).

#### ***Total sugar***

An amount of 50 ml of the clarified solution was pipette into a 100 ml conical flask and to it 2gm of citric acid was added and was boiled gently for 10 minutes to complete the inversion of sucrose and was cooled and transferred to a 100 ml volumetric flask. The solution was neutralized with 1n NaOH using phenolphthalein as indicator. For inversion at room temperature (20<sup>0</sup>C or above) for 24 hours and then neutralized with concentrated NaOH solution and volume was made up to 100 ml.

#### ***Estimation of mineral content by dry ashing method***

The minerals were analyzed from solutions obtained by fits' dry-ashing the powder of tomato. About 0.5 g of dried samples was transferred into a crucible and ashed in a muffle furnace at 600<sup>0</sup>C for 3 hours. The ash obtained was boiled with 12.5 ml hydrochloric acid in a beaker, filtered into a 100 ml volumetric flask and made up to the mark with distilled water. Phosphorus was determined by using spectrophotometer (JASCO V-630). All determinations were done in triplicate. For phosphorus determination, 2 ml of Ammonium Molybdate vanadate and 5 ml of 5 M hydrochloric acid were added to 2 ml of the stock solution. The concentration of phosphorus was determined through

the measurement of the yellow phosphor vanado-molybdate complex using Cecil Carating Digital Spectrophotometer Series

#### ***Determination of vitamin-C***

Vitamin-C was determined by the titration method as described by Rangana (1992). For this, 10 ml of sample was taken in a volumetric flask and made up to the volume 100 ml with 3% Meta phosphoric acid and filtered. Pipette 10 ml of filtrate into a conical flask and titrated with the standard dye solution to a pink end-point.

#### ***Determination of total carotenoids***

Total Carotenoids was determined according to Delia *et al.* (2004). Total Carotenoid contents for all the samples under study were estimated by the standard procedure followed in harvest plus research (Delia *et al.*, 2004). Here we used spectrometric method to estimate total Carotenoid content in samples.

#### ***Organoleptic evaluation of dehydrated tomato***

After the preparation of tomato powder, 4 samples were selected for organoleptic evaluation according to the method as described by Stone (1985). The Organoleptic evaluations of tomato powder were carried out by 10 judges. All the judges formed the panel were conversant with the factor governing the quality of the sample. Tomato powder was evaluated organoleptically for color, flavor, texture and overall acceptability. The taste panelists were asked to rate the samples for color, flavor, texture and overall acceptability on 1-9 point hedonic scale, when, 9=like extremely; 8=like very much; 7=like moderately; 6=like slightly; 5=neither like nor dislike; 4=dislike slightly; 3=dislike moderately; 2=dislike very much; 1=dislike extremely.

## **Results and Discussion**

#### ***Effect of pretreatments on dehydration process efficiency***

The effect of different pretreatments on dehydration process efficiency or percent yield of (solids gain or water loss) tomato powder is presented in Table 1 and Fig.2. From the table and figure, it can be seen that higher efficiency (solid content 4.6%) was obtained when the raw tomatoes pretreated with Calcium Chloride ( $\text{CaCl}_2$ ) along with Potassium Metabisulphite (KMS) than the tomatoes pretreated with  $\text{CaCl}_2$  (4.36%) and KMS (3.83%). The control samples which were not pretreated reported only 4.09 % recovery. Narsing Rao *et al.* (2008) reported that drying of 24 kg of fresh mature ripe tomatoes achieved 1.38 kg (5.75%) of dried tomato powder which was higher than that of our values. The reason

of higher efficiency might be due to the interactions of chemicals (salt and preservatives) and constituents of tomato.

#### ***Drying characteristics***

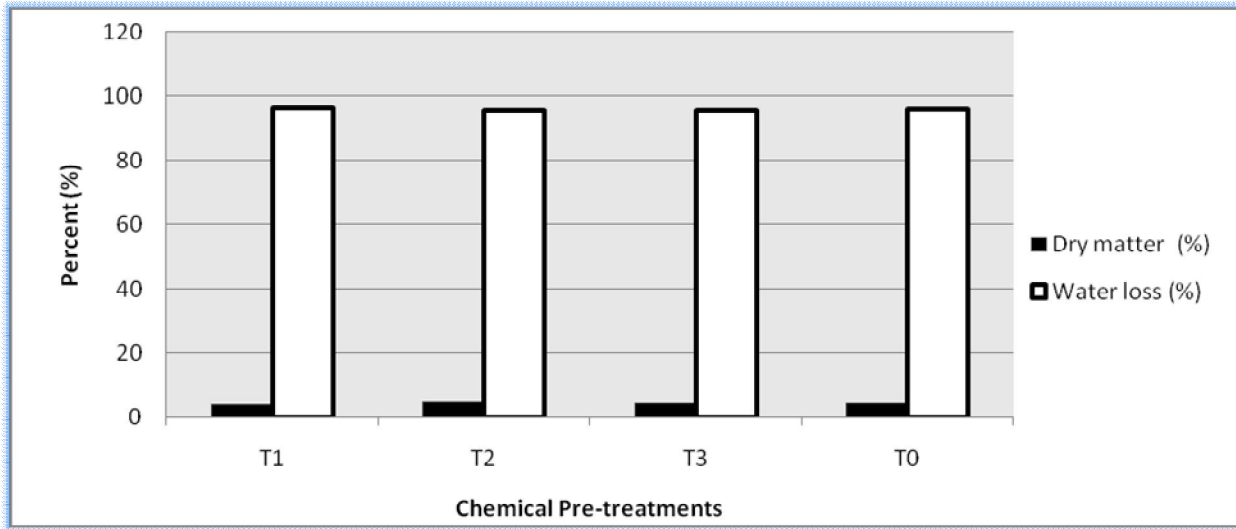
The moisture contents of various chemically pre-treated tomato samples were studied and drying rate curves as a function of drying time at constant temperature for dehydrated tomato pre-treated 0.2% KMS plus 1%  $\text{CaCl}_2$  and control sample were plotted (Fig. 3) based on their higher dehydration efficiency. There was an initial moisture content of  $95\% \pm 1$  in fresh tomatoes during the initial phase of drying and with the increases of time the final moisture content was reduced to 6-7% for sample treated 0.2% KMS plus 1%  $\text{CaCl}_2$  with until no further changes in their mass were observed. The times needed to reach the final moisture content for treated and non-treated samples were  $24 \pm 2$  hours. The drying rate curve was identical and similar to previous study as reported by Hema *et al.* (2007). In the early period of drying, there was a rapid decline in the moisture content for all the pieces of tomatoes. As expected the drying time decreased considerably with an increase in the air temperature.

#### ***Quality characteristics of dehydrated tomato***

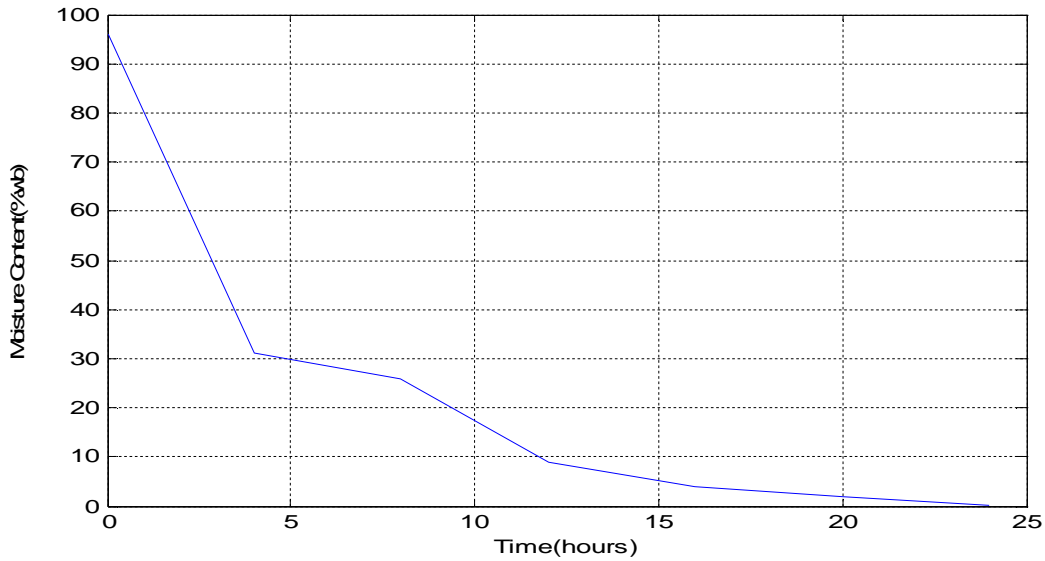
The characteristics of dehydrated tomato powder as affected by pre-drying treatment are presented in Table 2. Sample pre-treatment with Calcium Chloride ( $\text{CaCl}_2$ ) and potassium metabisulphite increased water removal and moisture mobility in tomato slices during drying and influenced the drying kinetics of tomato and their dehydration ratio which was evident by changing in texture of dip treated tomatoes. In comparison with these pre treatments, control samples showed higher final moisture content (6.9% with dehydration ratio 15.50) even with one hour longer period of dehydration process. Similar observations were reported by Olorunda *et al.* (1990). The fat contents of tomato powder treated with  $\text{CaCl}_2$ +KMS had higher (3.9%) fat than the others because of its lowest moisture content (Table 3). The same fat content (2.8 g/100 g) was observed in both samples pre-treated with KMS and  $\text{CaCl}_2$  independently. The protein content of the different samples treated with KMS,  $\text{CaCl}_2$ , KMS+ $\text{CaCl}_2$  and control were 12.6%, 13.1%, 13.9% and 12.4%, respectively. The protein content of the sample treated with KMS+ $\text{CaCl}_2$  was higher (13.9%) than the other samples. Changes in protein content might be related to reactions. i.e., non-enzymatic browning which was found to be more in control samples and less in  $\text{CaCl}_2$  + KMS treatment. Narsing Rao *et al.* (2008) observed that protein content of tomato powder was 12.65%. Sample treated with

KMS+CaCl<sub>2</sub> contains higher ash content (10.72 g/100 g) while sample treated with CaCl<sub>2</sub> showed lower ash content (10.21g/100g). The higher crude fiber content (6.5g/100g) was observed in KMS+CaCl<sub>2</sub> treated sample and the lower crude fiber was observed in

control sample (5.9 g/100g). Narsing Rao *et al.* (2008) reported that the crude fiber content of tomato powder was 9.78 g/100g, which was higher than that reported in the present study.



**Fig. 2.** Process efficiency of the different treatment (Percent recovery)



**Fig. 3.** Drying Curve for Tomatoes treated with 0.2% KMS plus 1% CaCl<sub>2</sub>



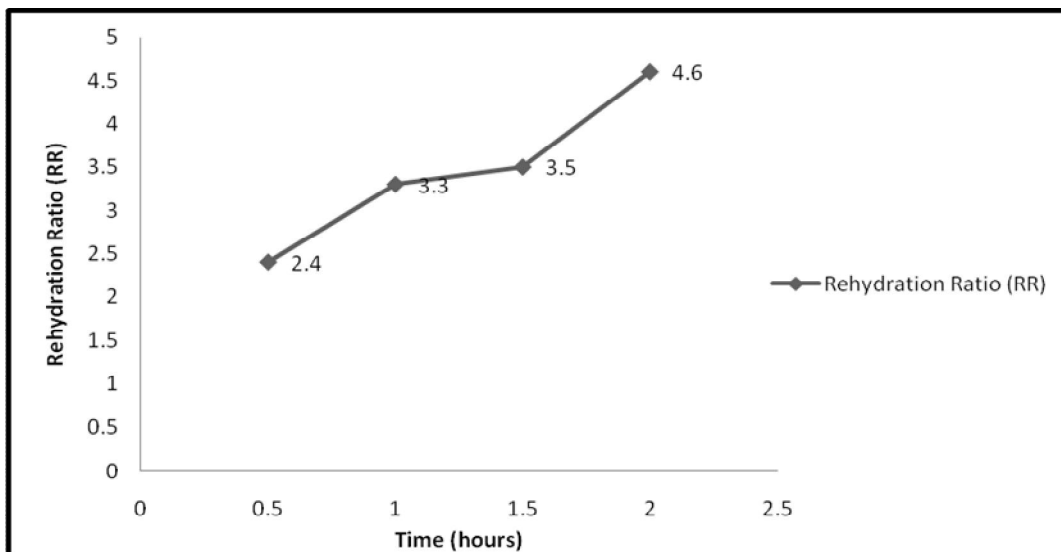


Fig. 4. Rehydration Ratio of dehydrated tomato (T<sub>3</sub>) treated with 0.2% KMS plus 1% CaCl<sub>2</sub>

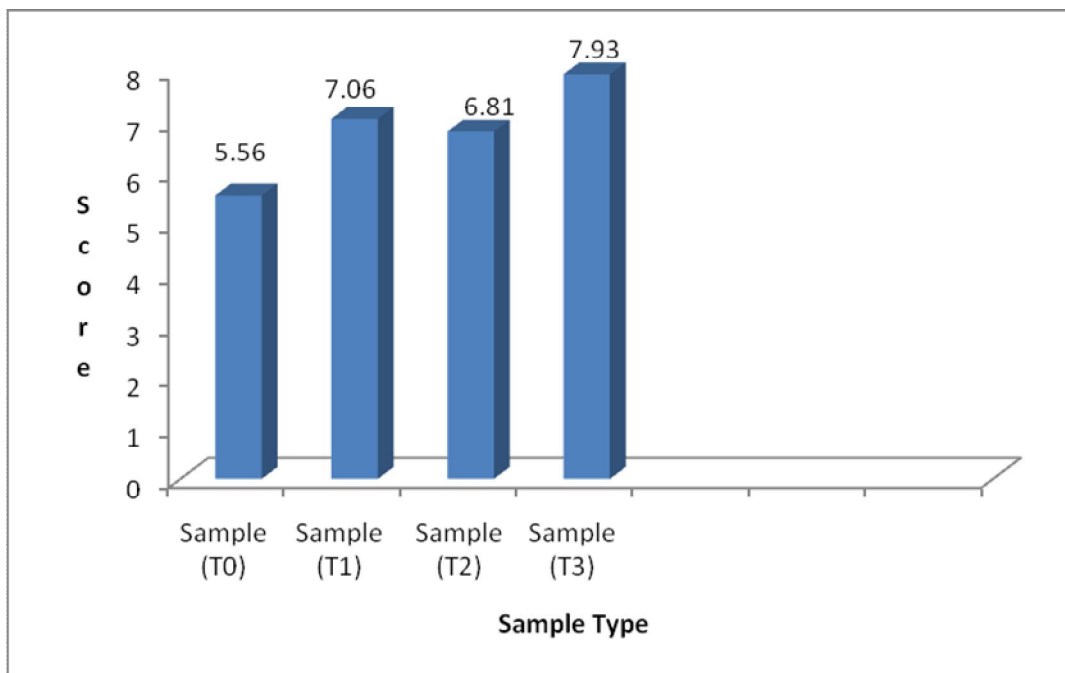
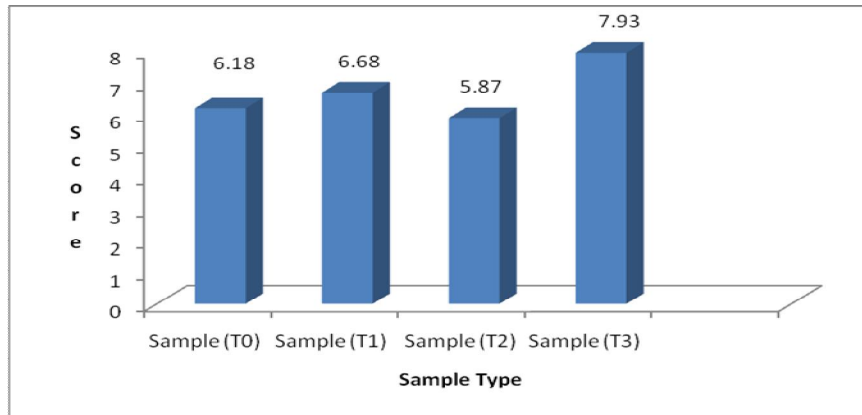
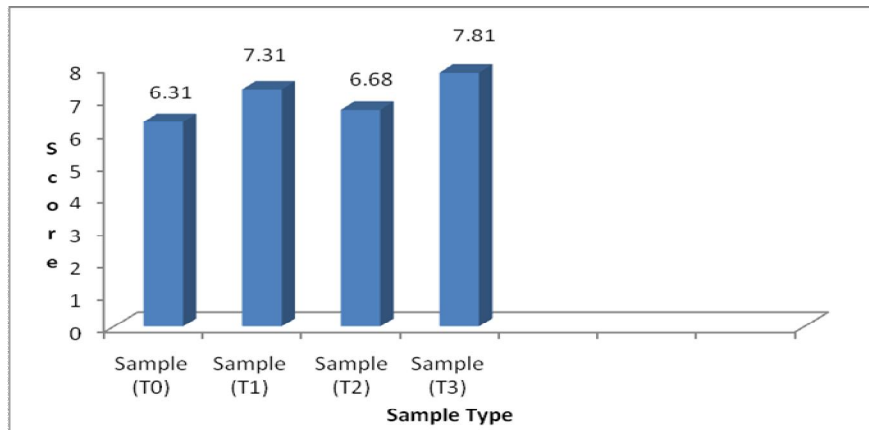


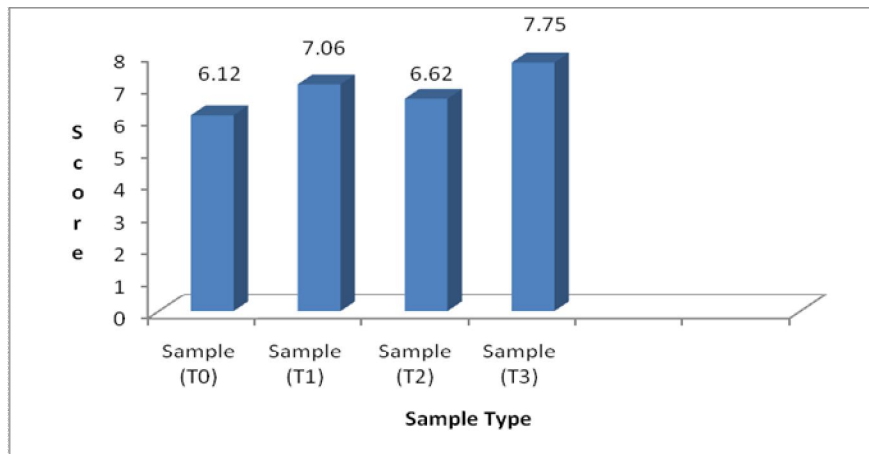
Fig. 5. Acceptability of color preference based on mean score



**Fig. 6.** Acceptability of flavor preference based on mean score



**Fig. 7.** Acceptability of texture preference based on mean score



**Fig. 8.** Acceptability of overall preference based on mean score

Calcium (336.672 mg/100 g), phosphorus (105 mg/100g) and iron (12.23 mg/100 g) contents in tomato powder are presented in Table 3. Narsing Rao *et al.* (2008) reported that the Calcium and iron were 212mg/100 g and 7.5mg/100 g, respectively. The total Carotenoid content of tomato powder was 210 µg/100 gm. A study reported that the total Carotenoids content (including β-carotene and lycopene) of cherry tomatoes dried at a temperature of 60<sup>0</sup> C was about 0.36 mg/g. Furthermore, total Carotenoid content of hot-air-dried pumpkin and carrot at 60<sup>0</sup> C were 0.14 mg/g and 1.1 mg/g respectively. Data presented in table 3 expressed that the vitamin C content of tomato powder was 35.30 mg/100g. Lavelli *et al.* (1999) reported that the content of ascorbic acid decreased from 3300 mg/kg of dry matter in fresh dried tomatoes at temperature 80<sup>0</sup> C. Toor and Savage (2006) investigated that drying tomatoes at 42<sup>0</sup> C during 18 hours led to ascorbic acid losses between 17-27% according to tomato varieties.

The sugar contents in all pre-treated tomato samples were found to be higher than the control sample. Calcium Chloride (CaCl<sub>2</sub>) along with potassium metabisulphite (KMS) pre-treated samples showed higher sugar content (49.1 g/100 g) followed by CaCl<sub>2</sub> which was 48.7 g/100g. The lowest value was 48.1 g/100 g. The changes in sugar content may be related to two reactions. i.e., non-enzymatic browning which was found to be more in control samples and less in CaCl<sub>2</sub>+KMS treated sample. The results obtained in our study are in a good agreement with those reported by Gupta & Nath (1984) and Gallali *et al.* (2000). From the Table 3, the sample pre-treated with potassium metabisulphite sample showed slightly more acidity (6.28%) as compared to the control sample (6.12%) while tomato powder pre-treated with CaCl<sub>2</sub> had lower acidity (5.86%). Similar observation has been reported by Okanlawon (2002). Drying methods carried out by cabinet drier indicate higher acidity in samples, which are supposed to be related to the partial fermentation, occurred in some trials, due to longer time consumption and pectic enzyme activity in first hours of the drying process.

Rehydration is the phenomenon that decides the effectiveness of the final product. The result of rehydration of the chemically treated samples (T<sub>3</sub>) is given in Fig. 4. It is clear from Fig. 4 that the rehydration ratio is significantly affected by chemical pretreatment; gradually increased with time and water uptake. The behavior of rehydration ratio of osmotically dehydrated carrot cubes was explained by Singh *et al.* (2007) on the basis that, the osmotically pretreated samples contain 8-12 % solute which got

infused during osmotic dehydration and leached in to water during rehydration process without contributing to the rehydrating process

#### **Sensory evaluation of tomato powder**

The degree of difference among the samples was compared by Duncan's Multiple Range Test (Table 4) and the graphical presentation of scores for color, flavor, texture and overall acceptability are given in Figure 5 to 8. Sample (T<sub>3</sub>) gave the highest score in respect of colour, flavor, texture and overall acceptability followed by other samples. The Least Significant Difference (LSD) is the highest between [samples (T<sub>3</sub>)] texture and overall acceptability. It indicated that the tomato powder prepared from sliced with KMS treatment is highest in quality aspect. A two way analysis of variance (ANOVA) was carried out for color, flavor, texture and overall acceptability preference and results revealed that there were significant (p<0.1) differences in color, flavor, texture and overall acceptability among the tomato powder. In case for color preference, the color of different samples of tomato powder was not equally acceptable. As shown in Table 4, the sample (T<sub>0</sub>) secured the lowest score (5.563) for the color preference than other samples. Sample (T<sub>3</sub>) secured the highest score (7.93). As shown in Table 4 for flavor preferences, the sample (T<sub>2</sub>) secured the lowest score (5.875) for the flavor preference. Sample (T<sub>3</sub>) secured the highest score (7.93). In case for texture, the sample (T<sub>3</sub>) is secured the highest score (7.81) for the texture preference while sample (T<sub>0</sub>) secured the lowest score (6.31). The overall acceptability of different samples of tomato powder was equally acceptable as shown in Table 4.

#### **Conclusions**

The cabinet drying technique was applied for dehydration of tomato slices at 60<sup>0</sup> C for 24±2 hours. CaCl<sub>2</sub> increased water removal rate than the other pretreatment during dehydration and slightly brown color was developed in the control sample. KMS together with CaCl<sub>2</sub> improved the quality of dehydrated slices. Finally, powder was prepared from dehydrated tomato slices and packed into normal polyethylene bags for storage study and utilization. CaCl<sub>2</sub> revealed higher percent recovery of tomato powder (4.60%) than KMS along with CaCl<sub>2</sub> (4.36%) and control (4.09%). However, KMS treated sample showed lowest percent recovery (3.83%). The vitamin-C of the developed tomato powder was quite lower than fresh tomato. The lower value of vitamin-C or the damage of vitamin during drying was primarily due to heat, oxidation and light. Sensory

evaluation of tomato powder was carried out, there was no significant difference in regards to flavor, texture as well as overall acceptability among the samples but significant difference was observed in terms of color among the samples. KMS along with CaCl<sub>2</sub> treated sample showed the better color than other samples.

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