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Effect of different pretreatments and air-temperatures on quality of green chilli powder

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Abstract
Studies were undertaken to evaluate the quality of green chilli powder by using different chemical pretreatments and air drying temperatures in tray dryer. Fresh green chillies were given horizontal cuts of 1cm in order to improve the drying rate after blanching. The chillies were pretreated with blanched in hot water at 90 ºC for 3 minutes, solution containing 1% citric acid, 0.3% sodium metabisulphite, 0.3% sodium metabisulphite and 1% citric acid were subjected to tray drying at different temperatures i.e., 50, 60 and 70 °C. The drying time and drying rate were calculated and compared. Proximate analysis was also carried out like total soluble solids, TA, reducing sugars, ascorbic acid and pH. The results showed the Titratable acidity slightly increased with the increase in drying temperature was found to be almost similar at 50, 60 and 70 °C with no significant variation for both control and pretreated samples. Using NaMS at drying air temperature of 60 °C provide more bright green colour as sulphite inhibits the non-enzymatic browning reaction. In order to obtain acceptable colour value and minimum nutrient losses in green chilli powder the pretreatment of NaMS combined with citric acid can be used with drying temperature of 60 °C.

Keywords: Chillies, tray dryer, chemical pretreatments, drying air temperatures, quality

1. Introduction

Chilli (*Capsicum annum* L.) from family Solanaceae, is one of the universal spices and is grown in almost all states of India for domestic market and export purpose. The world production of chilli crop to around 7 million tonnes, which is cultivated on 1.5 million hectares of land. India shares in global production ranges between from 50 to 60%. Andhra Pradesh area under cultivation and production of chillies are 602.0 thousand tonnes and 131.3 thousand hectares. Chillies are the rich source of vitamins, proteins and minerals. These are also good in B-complex group of vitamins such as niacin, pyridoxine, riboflavin and thiamin. Chilli has health benefiting alkaloid compound in them known as capsaicin which gives strong spicy pungent character.

Drying of fruits and vegetables is one of the most time and energy consuming processes. Drying rate must be accelerated to reduce the drying process and energy consumption without compromising the quality. Mechanical drying produces more consistent quality product taking less time and minimizing crop losses (Wiriya *et al.*, 2009) [10]. With appropriate choice of temperature and time variation, it is possible to reduce the overall colour change while maintaining higher drying rates (William *et al.*, 2008) [11].

Chillies are highly perishable, easily ripen in short time. As pretreatments are prerequisite for preserving, it is very much essential to enhance the utility of nutritional economic source. Chemical pretreatments involve the immersion of the product in acidic, alkaline, oleate esters or other chemicals for definite time duration prior to drying. It has also been reported that pretreatments can accelerate the drying rate by dissociating the wax and forming the fine cracks on the surface of the material for easy moisture removal. Chemical pretreatments, in particular sulfite solutions, were found to improve color stability of chilli, and a combination of chemical solutions containing inhibited the browning reaction of chilli. In addition, a stepwise temperature method was found to improve color and nutrition quality of dried products.

Hence, the objective of the present study was to study the effect of different drying air-temperatures and chemical pre-treatments on quality of green chilli powder.

Literature on usages of green chilli and its products is limited. The increasing demand of processed ready to eat and ready to cook products has resulted in growing industry of Indian spices.

Dehydrated and chemically pretreated green chilli powder has extended shelf life and can be easily incorporated in various homemade recepies like red chilli powder. Chilli powder is used by the food manufacturing industry and confectionery for preparation of sauces, pickles, ketchup and other fast foods. Thus there is potential to explore the technology for processing of green chilli which can retain delicate fresh flavour.

Bakane *et al.* (2014) [3] studied the effect of different pretreatments on drying characteristics of green chilli. The green chilli were washed and cut into 5-7 mm long pieces. These pieces were dried in dehumidified air dryer after pretreatments namely control, blanching and sulphitation (0.5% of KMS). Green chilli dried in dehumidified air dryer from its initial moisture content 516.84-624.11 per cent (db) to final moisture content 8.61-9.85 per cent (db). The drying rate was faster in blanched samples as compared to other samples. The dehydration ratio was found to be less in control and sulphited sample as compared to blanched sample. The rehydration ratio of blanched sample was found to be lowest as compared to other sample. Green chilli dried in dehumidified air dryer was found to be better on the basis of sensory evaluation.

Wiriya *et al*. (2009) [10] studied the drying air temperature and chemical pre treatments on quality of dried chilli. The quality of dried chilli (*Capsicum annum cv. Huarou Yon*) in terms of color attributes and nutrients was studied using a lab-scale tray dryer in order to reduce the quality loss caused by sun drying. Different drying temperatures from 50-70 °C and a two stage temperature regime (70 and 50 °C) were used to compare with the sun drying method. A one-temperature regime provided low values of lightness, chroma and hue angle compared to sun drying. The two-stage temperature provided bright red colored dried chilli.

2. Materials and Methods

The local variety of fresh chillies was purchased from market. Grading is done manually to remove the undersized, black and spoiled chillies to get the good quality green chilli powder from the fresh green chillies. The green chillies were washed under tap water to remove adhering impurities. The chillies were given horizontal cuts of 1cm in order to improve the drying rate after blanching. The green chillies were pretreated in hot water at 90°C for 3 minutes (blanching), solution containing: 0.3% sodium metabisulphite (NaMS), 0.3% sodium metabisulphite (NaMS) and 1% citric acid. The ratio of the green chilli: pretreatment solution is 250 g: 1 Litre.

For drying of green chillies, the HUMIDDRY Tray Dryer (TD-12-S-E), Electric heating model having 6 kW power and temperature 200°C was used. The green chillies are spread uniformly inside the tray dryer until the moisture content lowered down for safe storage. Reduction in weight due to moisture losses was recorded continuously at every 30 min interval during drying. A hot air oven, electrically heated and thermostatically controlled, was used for measurement of moisture tests. Standard AOAC (1990) method was followed. Drying was continued until there were no large variations in their weights. The drying experiment was repeated in tray dryer at temperatures of 50, 60 and 70°C. The tray dried green chillies were collected and powdered by using Willey mill. The ground powder was collected and sieved to obtain fine powder.

2.1 Calculation of Drying Rate

Drying rate is defined as the ratio of moisture removed per kg of dry weight of material in unit time. The amount of moisture removed on each of experimentation is initially determined and then the drying rate is calculated. It is computed for different temperatures of drying during experiment for each day using the following formula:

$$R = \frac{dm}{d\theta} = \frac{\text{amount of moisture removed}}{\text{time taken (h) X Bone dry weight of the sample}}$$

The overall drying rate of each temperature is also calculated by considering initial and final moisture content of the green chillies.

2.2 Water activity

The moisture sorption isotherms describe relationship between water activity and the equilibrium moisture content for a food product to a constant pressure and temperature. Water activity was recorded by Aqualab water activity meter (Model series 3TE) and the readings were corrected at 20 °C. However, the moisture was recorded by the method described by AOAC, 1995.

2.3 pH

The pH measurement was performed using a Digital pH meter (Systronics µ pH system 362) using a glass electrode. The electrode was placed inside the homogenized sample of green chilli powder and the value was registered once it had stabilized. This pH was measured for ever three days until the end of storage period and the values were recorded (Ranganna. 1995) [7].

2.4 Reducing sugars (%)

The reducing sugars were estimated by using Lane and Eynon (1923) [6] method with modification suggested by Ranganna (1995) [7]. A known weight (5 g) of sample was blended with distilled water using lead acetate (45%) for precipitation of extraneous material and potassium oxalate (22%) to remove the lead from solution. This lead-free extract was used to estimate reducing sugars by titrating against standard Fehling's mixture (Fehling's A and B) using methylene blue as an indicator to a brick red end point. It was expressed in %.

$$\text{Re}\,\textit{ducing sugars},\% = \frac{\textit{Factor} \times \textit{Dilution} \times 100}{\textit{Titre reading} \times \textit{Weight of sample}}$$

2.5 Total soluble solids

Total soluble solids (TSS) of chilli were analyzed by Digital Refractometer (Rudolph, USA) and the total soluble solids were recorded as °Brix. Correction at 20 °C was applied for the observed reading by following the method given by AOAC, 2005.

2.6 Titratable acidity

Total acidity was determined by titrating the sample extracted in distilled water against 0.1N sodium hydroxide using phenolphthalein as indicator by following the method given by AOAC, 1990. Appearance of light pink colour denotes the end point. The acidity was calculated by using following equation and expressed in % citric acid.

$$\text{Titratable acidity (\%)} = \frac{\text{Equivalent weight of acid} \times \text{Normality of NaoH} \times \text{Titre} \times 100}{\text{Weight of sample} \times 1000} \times \text{D.F}$$

Where
D.F= Dilution factor

2.7 Ascorbic acid
Ascorbic acid was estimated by the method as described by Ranganna, 1995 using 2, 6-dichlorophenol indophenol dye. Dye factor was calculated by titrating 5 mL standard ascorbic acid plus 5 mL (3%) metaphosphoric acid against 2, 6-dichlorophenol indophenol till pink colour appeared and volume used was noted.

$$\text{Dye factor} = \frac{0.5}{Titre\ value}$$

Ascorbic acid was estimated by taking 5g of sample, volume made upto 100 mL with (3%) metaphosphoric acid and filtered. Then aliquot of 10 mL was taken in a titration flask and titrated against 2, 6-dichlorophenol indophenol till light pink colour appeared (which persisted for 15 seconds).

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre value} \times \text{dye factor} \times \text{volume made up}}{\text{ml of filtrate taken for} \times \text{weight of sample estimation}} \times 100$$

3. Results and Discussion
3.1 Drying Rate
Tray drying of green chillies at 50, 60 and 70 °C (without pretreatment)

The variations of drying rate with drying time and drying temperatures are shown in Fig. 1. The graphs indicate that, drying is taking place in falling rate regime irrespective of drying method. The absence of initial constant rate of drying suggests that drying may have occurred both by diffusion and capillary action as observed in most agricultural materials (Chakravarthy, 1987) [4].

From Fig. 1, it is clear that the drying rate is more at drying temperature 70 °C followed by 60 and 50 °C. Also observed that drying rate increases with increase in temperature. The average drying rate of green chilli during the experiment at 70 °C is 0.00445 g/g-min whereas the average drying rate of green chilli during the experiment at drying temperature 60 and 50 °C were 0.00426 and 0.00407 g/g-min respectively.

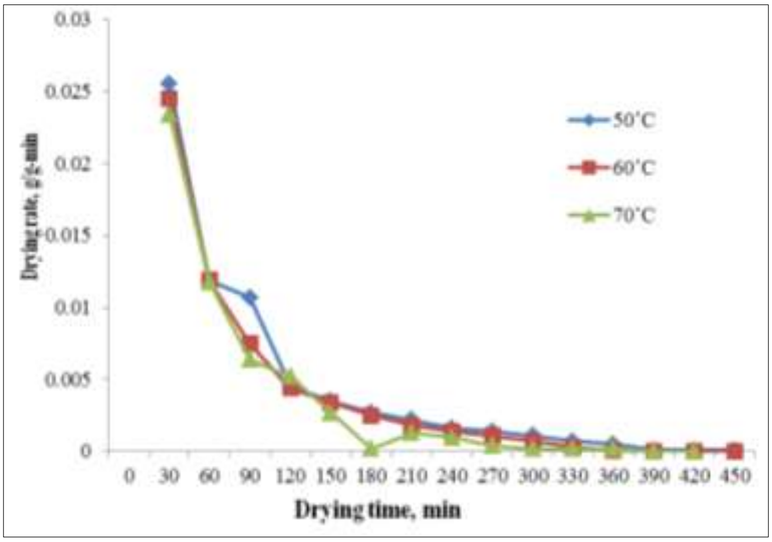

Fig 1: Variation of drying rate with drying time in Tray dryer at different air-temperatures with control (without pretreatment)

3.2 Tray drying at 50, 60 and 70 °C with blanching treatment
The drying in falling rate period showed that internal mass transfer occurred by diffusion. It was observed that moisture with time while drying rates were higher at higher drying temperatures. In some cases, drying rate was initially less, and later on remained constant for some time. The period for which drying rate initially increased is known as heating period.

The variations of drying rate with drying time and drying temperatures are shown in Fig. 2. From the figure it is clear that the drying rate is more at drying temperature 70 °C followed by 60 and 50 °C. The average drying rate of green chilli during the experiment at 70 °C is 0.00432 g/g-min whereas the average drying rate of green chilli during the experiment at drying temperatures 60 and 50 °C were 0.00407 and 0.00406 g/g-min respectively.

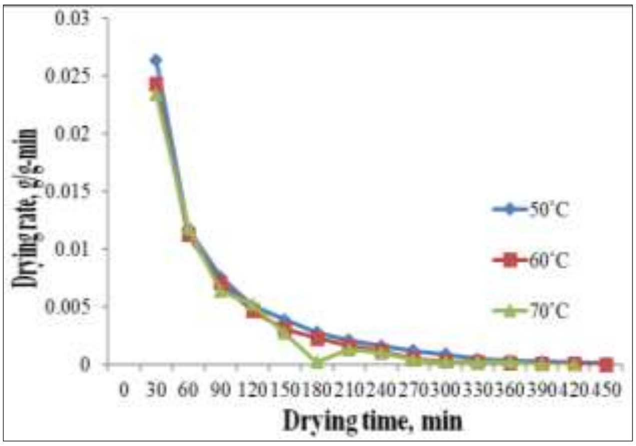

Fig 2: Variation of drying rate with drying time in Tray dryer at different air-temperatures with blanching pretreatment

3.3 Tray drying at 50, 60 and 70 °C with NaMS pretreatment

The drying rate decreased continuously throughout the drying period. It is obvious from Fig. 3, which the constant rate period was absent and the drying process of green chilli took place in falling rate period. These results are in good agreement as compared to the earlier studies on herbal leaves by Doymaz *et al*., 2002 [5].

The variations of drying rate with drying time and drying temperatures were shown in Fig. 3. From the figure it is clear that the drying rate is more at drying temperature 70°C followed by 60 and 50 °C. The average drying rate of green chilli during the experiment at drying temperature 70°C is 0.00467 g/g-min whereas the average drying rate of green chilli during the experiment at drying temperature 60 and 50 °C were 0.00425 and 0.00407 g/g-min respectively.

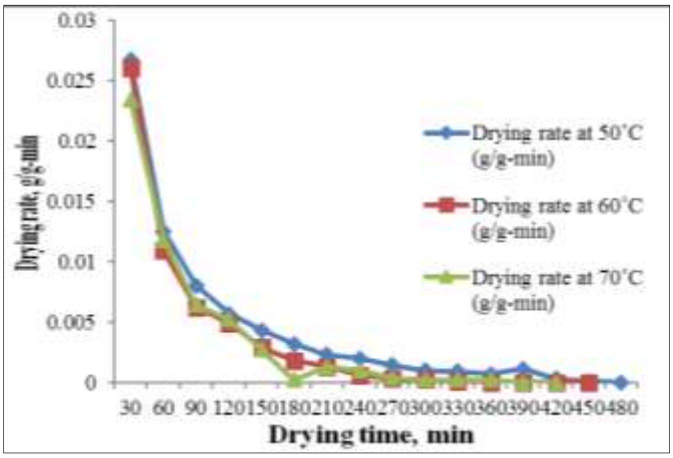

Fig 3: Variation of drying rate with drying time in Tray dryer at different air-temperatures with NAMS pretreatment

3.4 Tray drying at 50, 60 and 70 °C with NAMS + Citric acid pretreatment

The variations of drying rate with drying time and drying temperatures were shown in Fig. 4. From the figure, it is clear that the drying rate is more at drying temperature 70 °C followed by 60 and 50 °C. The average drying rate of green chilli during the experiment at 70 °C is 0.0042 g/g-min whereas the average drying rate of green chilli during the experiment at drying temperature 60 and 50°C were 0.00403 and 0.00398 g/g-min respectively.

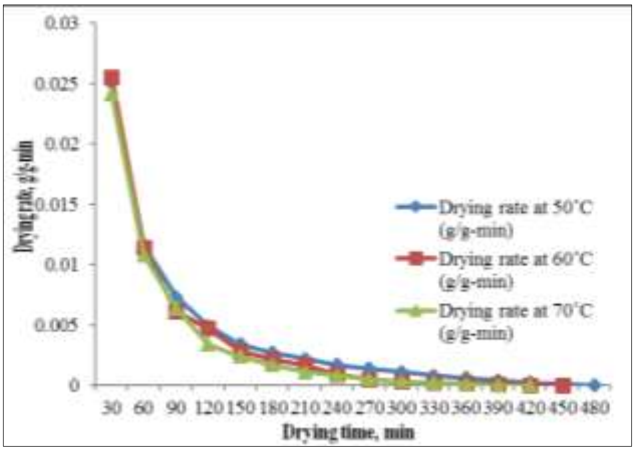

Fig 4: Variation of drying rate with drying time in Tray dryer at different air-temperatures with NAMS + Citric acid pretreatment

3.5 Effect of water activity for control and pretreated samples

The observed values of water activity for chilli powder dried at different temperatures i.e. 50, 60, 70 °C for both control and treated samples are shown in Fig. 5. The initial value of water activity for fresh green chilli is 0.99. All the samples met the safe level of moisture activity (aw<0.7) where no microorganisms can multiply (Samogyi and Luh, 1975) [9]. It was observed the values of water activity are less at the temperature of 60°C when compared to other pretreatments at different temperatures. And also the highest water activity was observed in control (without pretreatment).

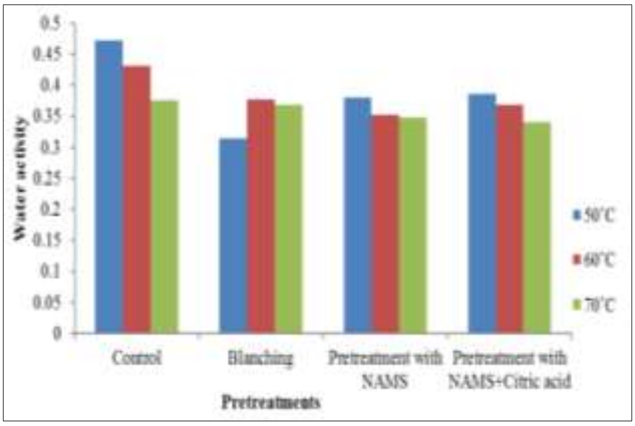

Fig 5: Variation of water activity at different air-temperatures for both control and pretreated samples

3.6 Effect of pH for control and pretreated samples

The observed values of pH for chilli powder dried at different air-temperatures i.e. 50, 60, 70 °C for both control and treated samples were shown in Fig. 6. The pH of fresh chilli was 5.7. It was observed from the figure, the pH was high at drying temperature 50 °C of NaMS pretreatment compared to other samples.

The pH of all dried chilli samples varied between 4.29 to 5.06. However, variations of pH and total acidity are possible due to variations caused by contamination from microorganisms. Microorganisms, mainly lactic acid bacteria, produce organic acids, which then increase in total acidity content and decrease in pH value.

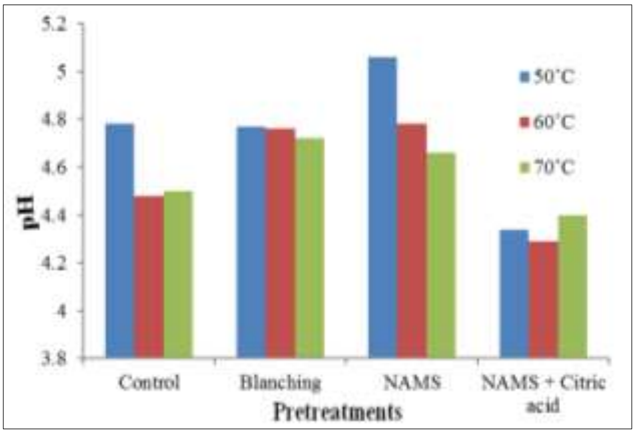

Fig 6: Variation of pH value at different air-temperatures for control and pretreated samples

3.7 Effect of reducing sugars for control and pretreated samples

It was observed from the Fig. 7, the reducing sugar levels of the chilli were between 35 to 80 mg/g dried chillies. Even though different drying air-temperatures did not significantly affect reducing sugar, the decrease in reducing sugar resulted in the forming of browning compounds due to the non-enzymatic browning reaction between reducing sugar and amino acid.

Reducing sugar content of dried chilli obtained from different chemical pretreatments was quite different using drying air temperatures of 50, 60 and 70 °C, but reducing sugar content were significantly decreased compared with the control sample. Meanwhile, using chemical substances with the three drying temperatures method proved to improve the amount of reducing sugar of dried chilli compared to control sample. It is suggested that the degradation of the reducing sugar causes the browning pigment to develop due to a maillard reaction, and therefore a decrease in lightness and color was observed.

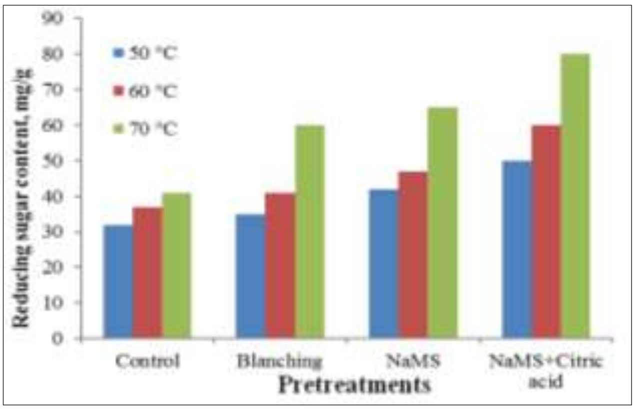

Fig 7: Variation of reducing sugars at different air-temperatures for control and pretreated samples

3.8 Effect of TSS on control and pretreated samples

The observed values of TSS for chilli powder dried at different temperatures i.e. 50, 60, 70 °C for both control and treated samples were shown in Fig. 8. The initial value of TSS for fresh green chilli is 13.8 °Brix. Total soluble solids (TSS) among different treatments varied between 10.50 and 14.0 °Brix. It can be observed from graph, the Total soluble solids increased with increase in drying temperature.

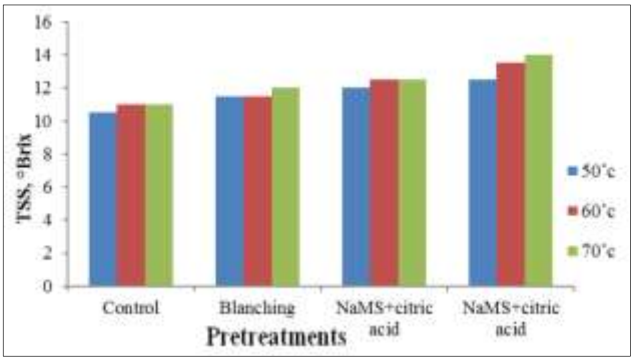

Fig 8: Variation of TSS at different air-temperatures for control and pretreated samples

3.9 Effect of Titratable Acidity (TA) for control and pretreated samples

The observed values of TA for chilli powder dried at different temperatures i.e. 50, 60, 70 °C for both control and treated samples are shown in Fig. 9. The initial value of TA for fresh green chilli is 0.25%.

Blanching of dried chilli samples prior to drying produced a product with lower acidity compared to the control sample while maximum titratable acidity was recorded in control at 70 °C. The loss of acid content in blanched samples could be due to leaching losses during blanching. It can be observed from Fig. 9, the Titratable acidity increased with the increase in drying temperature. During drying, increase in acidity was mainly attributed to the increased moisture loss from the sample with corresponding increase in temperature.

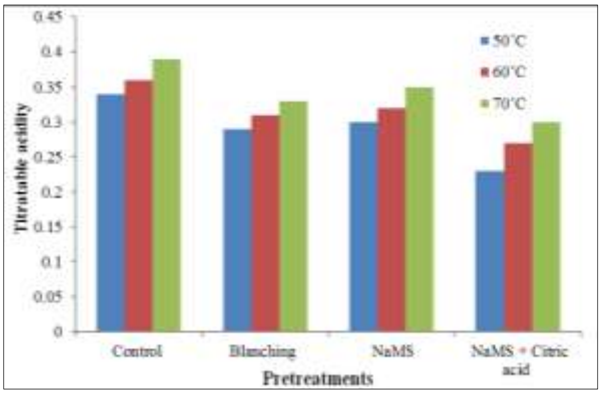

Fig 9: Variation of TA at different air-temperatures for control and pretreated samples

3.10 Effect of Ascorbic acid on control and pretreated samples

Ascorbic acid was degraded by higher temperatures and the degradation product (L dehydroascorbic acid, DHAA) could participate in Strecker degradation (a chemical reaction which converts an α-amino acid into an aldehyde) with amino acid, producing a browning pigment. Not only does the high temperature of drying air affect the loss of ascorbic acid, but a long period of drying time can also introduce a significant loss of ascorbic acid. It was observed from the Fig. 10, using a pretreatment method before drying could not prevent the degradation of ascorbic acid for 50, 60 and 70°C temperatures. Generally, ascorbic acid is used for food products as antioxidizing agent. This contradicted with these results, as the soaking of chilli in this solution was found to lead to a darker color, even though the amount of ascorbic acid was increased after the drying process.

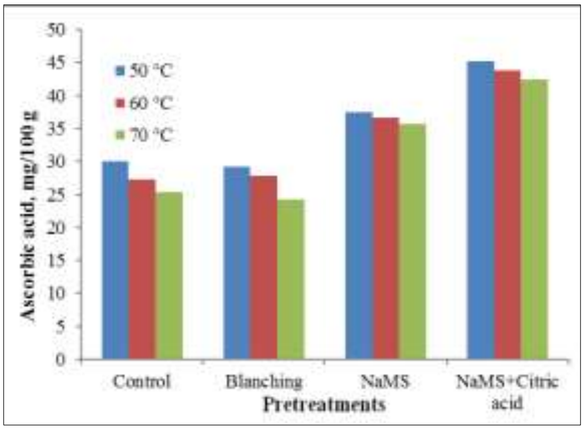

Fig 10: Variation of Ascorbic acid at different air-temperatures for control and pretreated samples

4. Conclusion
The time taken for drying of green chillies at 70 °C (420 min) was less as compared to 60 °C (450 min) and 50 °C (480 min) when subjected to both control and pretreated samples in tray dryer. It could be suggested that not only does the drying air-temperature affect nutrient stability, but also the drying time. Total soluble solids and Titratable acidity slightly increased with the increase in drying temperature for both control and pretreated samples. Reducing sugar could not be preserved by soaking in chemical solutions. Ascorbic acid was degraded at higher air-temperatures. All the samples at different temperatures met the safe level of water activity (aw<0.7) where no microorganisms can multiply. Using NaMS at drying air temperature of 60 °C provide more bright green colour as sulphite inhibits the non-enzymatic browning reaction. In order to obtain acceptable colour value and minimum nutrient losses in green chilli powder the pretreatment of NaMS combined with citric acid can be used with drying temperature of 60 °C.

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