Print ISSN : 0972-8813
e-ISSN : 2582-2780

[Vol. 21(2) May-August 2023]

Pantnagar Journal of Research

(Formerly International Journal of Basic and Applied Agricultural Research ISSN : 2349-8765)

G.B. Pant University of Agriculture & Technology, Pantnagar

ADVISORYBOARD

Patron
Dr. Manmohan Singh Chauhan, Vice-Chancellor, G.B. Pant University of Agriculture and Technology, Pantnagar, India
Members
Dr. A.S. Nain, Ph.D., Director Research, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. J.P. Jaiswal, Ph.D., Director, Extension Education, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. S.K. Kashyap, Ph.D., Dean, College of Agriculture, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. S.P. Singh, Ph.D., Dean, College of Veterinary & Animal Sciences, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. K.P. Raverkar, Ph.D., Dean, College of Post Graduate Studies, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. Sandeep Arora, Ph.D., Dean, College of Basic Sciences & Humanities, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. Alaknanda Ashok, Ph.D., Dean, College of Technology, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. Alka Goel, Ph.D., Dean, College of Home Science, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. Malobica Das Trakroo,Ph.D., Dean, College of Fisheries, G.B. Pant University of Agri. & Tech., Pantnagar, India
Dr. R.S. Jadoun,Ph.D., Dean, College of Agribusiness Management, G.B. Pant University of Agri. & Tech., Pantnagar, India

EDITORIALBOARD

Members
Prof. A.K. Misra, Ph.D., Chairman, Agricultural Scientists Recruitment Board, Krishi Anusandhan Bhavan I, New Delhi, India
Dr. Anand Shukla, Director, Reefberry Foodex Pvt. Ltd., Veraval, Gujarat, India
Dr. Anil Kumar, Ph.D., Director, Education, Rani Lakshmi Bai Central Agricultural University, Jhansi, India
Dr. Ashok K. Mishra, Ph.D., Kemper and Ethel Marley Foundation Chair, W P Carey Business School, Arizona State University, U.S.A
Dr. B.B. Singh, Ph.D., Visiting Professor and Senior Fellow, Dept. of Soil and Crop Sciences and Borlaug Institute for International Agriculture, Texas A&M University, U.S.A.
Prof. Binod Kumar Kanaujia, Ph.D., Professor, School of Computational and Integrative Sciences, Jawahar Lal Nehru University, New Delhi, India
Dr. D. Ratna Kumari, Ph.D., Associate Dean, College of Community / Home Science, PJTSAU, Hyderabad, India
Dr. Deepak Pant, Ph.D., Separation and Conversion Technology, Flemish Institute for Technological Research (VITO), Belgium
Dr. Desirazu N. Rao, Ph.D., Professor, Department of Biochemistry, Indian Institute of Science, Bangalore, India
Dr. G.K. Garg, Ph.D., Dean (Retired), College of Basic Sciences & Humanities, G.B. Pant University of Agric. & Tech., Pantnagar, India
Dr. Humnath Bhandari, Ph.D., IRRI Representative for Bangladesh, Agricultural Economist, Agrifood Policy Platform, Philippines
Dr. Indu S Sawant, Ph.D., Director, ICAR - National Research Centre for Grapes, Pune, India
Dr. Kuldeep Singh, Ph.D., Director, ICAR - National Bureau of Plant Genetic Resources, New Delhi, India
Dr. M.P. Pandey, Ph.D., Ex. Vice Chancellor, BAU, Ranchi & IGKV, Raipur and Director General, IAT, Allahabad, India
Dr. Martin Mortimer, Ph.D., Professor, The Centre of Excellence for Sustainable Food Systems, University of Liverpool, United Kingdom
Dr. Muneshwar Singh, Ph.D., Project Coordinator AICRP- LTFE, ICAR - Indian Institute of Soil Science, Bhopal, India
Prof. Omkar, Ph.D., Professor, Department of Zoology, University of Lucknow, India
Dr. P.C. Srivastav, Ph.D., Professor, Department of Soil Science, G.B. Pant University of Agriculture and Technology, Pantnagar, India
Dr. Prashant Srivastava, Ph.D., Cooperative Research Centre for Contamination Assessment and Remediation of the Environment, University of South Australia, Australia
Dr. Puneet Srivastava, Ph.D., Director, Water Resources Center, Butler-Cunningham Eminent Scholar, Professor, Biosystems Engineering, Auburn University, U.S.A.
Dr. R.C. Chaudhary, Ph.D., Chairman, Participatory Rural Development Foundation, Gorakhpur, India
Dr. R.K. Singh, Ph.D., Director & Vice Chancellor, ICAR-Indian Veterinary Research Institute, Izatnagar, U.P., India
Prof. Ramesh Kanwar, Ph.D., Charles F. Curtiss Distinguished Professor of Water Resources Engineering, Iowa State University, U.S.A.
Dr. S.N. Maurya, Ph.D., Professor (Retired), Department of Gynecology & Obstetrics, G.B. Pant University of Agric. & Tech., Pantnagar, India
Dr. Sham S. Goyal, Ph.D., Professor (Retired), Faculty of Agriculture and Environmental Sciences, University of California, Davis, U.S.A.
Prof. Umesh Varshney, Ph.D., Professor, Department of Microbiology and Cell Biology, Indian Institute of Science, Bangalore, India
Prof. V.D. Sharma, Ph.D., Dean Academics, SAI Group of Institutions, Dehradun, India
Dr. V.K. Singh, Ph.D., Head, Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi, India
Dr. Vijay P. Singh, Ph.D., Distinguished Professor, Caroline and William N. Lehrer Distinguished Chair in Water Engineering, Department of Biological Agricultural Engineering, Texas A& M University, U.S.A.
Dr. Vinay Mehrotra, Ph.D., President, Vinlax Canada Inc., Canada

Editor-in-Chief
Dr. Manoranjan Dutta, Head Crop Improvement Division (Retd.), National Bureau of Plant Genetic Resources, New Delhi, India

Managing Editor
Dr. S.N. Tiwari, Ph.D., Professor, Department of Entomology, G.B. Pant University of Agriculture and Technology, Pantnagar, India

Assistant Managing Editor
Dr. Jyotsna Yadav, Ph.D., Research Editor, Directorate of Research, G.B. Pant University of Agriculture and Technology, Pantnagar, India

Technical Manager
Dr. S.D. Samantray, Ph.D., Professor, Department of Computer Science and Engineering, G.B. Pant University of Agriculture and Technology, Pantnagar, India

PANTNAGAR JOURNAL OF RESEARCH

Vol. 21(2) May-August, 2023

CONTENTS

Physiochemical properties of pretreated tomato powder from different drying technique

SHRADDHA SETHI* and NEERAJ SETH

Department of Processing and Food Engineering, College of Agricultural Engineering and Technology, Anand Agricultural University, Godhra (Gujarat)
**Corresponding author's email Id: shraddhasethi06@gmail.com*

ABSTRACT: Tomato (*Solanum lycopersicon*) is a warm-season vegetable crop. Tomato contains a high amount of water about 95 percentage (%), which justifies its perishable nature Since tomatoes are particularly perishable, post-harvest losses are very substantial. The study presented a comprehensive investigation into the physiochemical properties of pretreated tomato slices with 0.5% sodium metabisulphite, sodium chloride, citric acid and distilled water using three drying methods: tray drying, sun drying, and combination drying (sun drying followed by tray drying). Results showed that the highest ascorbic acid content was 42.56 mg/100g, achieved through combination drying at 60°C.The highest level of protein content was 21.76 mg/100g, attained through sun drying. Highest carbohydrate content was 72.93 mg/100g, obtained through tray drying at 55°C.The highest lycopene content was 107.45 mg/100g, achieved through tray drying at 60°C. β-carotene content was highest with 42.40 mg/100g, obtained through tray drying at 55°C. The highest pH was 4.30, attained through sun drying and the highest total soluble solids (TSS) was 8.82, achieved through tray drying at 65°C.The highest level of ash content was 11.90%, obtained through sun drying. In conclusion, the study demonstrated that drying methods and temperatures significantly affected the nutritional content of tomato powder. Pre-treatment with sodium chloride and citric acid showed promising results in preserving various nutrients during the drying process.

Key words: Drying, physiochemical properties, powder, pretreatment, tomato

The Indian agricultural industry has witnessed remarkable growth in the vegetable sector, significantly enhancing food and nutritional security, especially for the underprivileged population. Among vegetables, tomatoes play a pivotal role, with India ranking as the world's second-largest producer after China, contributing 14% to global production. Despite this progress, per capita vegetable consumption in India remains below the recommended level, making efforts to improve postharvest management and value addition critical. Tomatoes, a warm-season vegetable crop, are recognized as "protective foods" due to their exceptional nutritional profile mentioned by Choudhary (1978). Rich in essential vitamins, minerals, and antioxidants like lycopene, tomatoes offer numerous health benefits. However, their perishable nature poses challenges in preventing post-harvest losses, especially during periods of oversupply. Tomatoes and its derivatives are generally good sources of essential nutrients, although low in iron and appear to have low levels of antinutrients including phytates, glycosides, saponins, and tannins mentioned by Chamoun *et al.* (2023).

To address these concerns, the current research paper focuses on exploring the best pretreatment and drying techniques for dehydrated tomato slices. Such preservation methods offer the advantages of extended shelf life, reduced transportation costs, and increased export potential. The study aims to improve the physiochemical qualities of dehydrated tomato slices, ensuring their long-term storage and availability without compromising their natural flavor, color, or texture. Additionally, the research strives to make effective use of abundant tomato production by value addition through dehydrated slices, benefiting both tomato growers and the processing sector. By identifying optimal drying processes and packing materials, the study aims to pave the way for further research in this area, given the relative scarcity of studies compared to other vegetables.

In light of the significance of preserving nutritional value and enhancing product quality, this research delves into the effects of pre-treatment on tomato slice drying, compares pre-treated and untreated slices using various drying technique for preparations of tomato powder. Ultimately, the findings of this study could contribute to the growing demand for processed tomato products, opening new avenues for the agricultural and food processing industries to meet future challenges.

MATERIALS AND METHODS

Tomatoes used for preparation of tomato powder were procured from the local market of India. These tomatoes were sorted and cleaned before use. The cleaned tomatoes were then sliced manually into 5mm slices with the help of a slicer. The statistical analysis used for the experiment was Completely Randomized Design (CRD).

Pretreatment of tomato slices

These 5mm tomato slices were sprayed with a solution of 0.5% w/v Sodium Metabisulfite, Sodium Chloride, Citric acid and Distilled water (control) for 10 minutes. At the end of the treatment period the slices were separated and excess water was drained. These slices were then subjected to the different drying methods.

Drying method

The pretreated tomato slices were then subjected to three drying methods viz., Tray drying at 55, 60, 65^0C temperatures, sun drying, combination drying (the slices were sun dried until the moisture content reached 50% then subject to tray drying for further drying process) at 55, 60, 65^0C temperatures.

Physiochemical parameters

Ascorbic acid

The ascorbic acid content of the samples was determined using the 2,6-dichlorophenolindophenol visual titration method described by Rangana (1986). A standard ascorbic acid solution was titrated with a dye solution until a pink color appeared and remained for 15 seconds. The ascorbic acid content in the sample was calculated using a formula based on the dye factor and volumes used in the titration.

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Dye factor} \times V_2 \times V_4 \times 100}{V_1 \times V_3} \quad ...(1)$$

Where,
mg/100g = milligrams per 100 grams
V_1 = Volume of sample extract taken for dye titration (millilitre, ml),
V_2 = Volume of the dye required (titre, ml),
V_3 = Volume of the sample taken for extraction with HPO_3 (ml),
V_4 = Volume made up (ml)

Protein content

The quantity of true protein in the tomato powder samples was evaluated using the Folin-Lowry method described by Lowry *et al.* (1951). The samples were extracted in Sodium Chloride (NaOH) solution, and then a series of test tubes with standard solutions and sample aliquots were prepared. Alkaline copper and Folin-Ciocalteau reagents were added, and the absorbance was measured at 660 nm (nanometers) using a spectrophotometer. The true protein content was calculated using a formula based on the standard graph and the absorbance readings.

$$\text{True protein (\%)} = \frac{\text{Graph factor } (\mu g) \times \text{Optical density} \times \text{Dilution factor} \times \text{Total vol. (ml)} \times 10\text{-}6}{\text{Sample aliquot (ml)} \times \text{Weight of sample (g)}} \times 100 \ldots(2)$$

Carbohydrate content

The total carbohydrate content of the tomato powder samples was determined using the phenol sulphuric acid method by Dubois *et al.* (1956). The samples were hydrolyzed with hydrochloric acid (HCl), and then a series of test tubes with standard solutions and sample aliquots were prepared. Phenol and sulphuric acid were added, and the color was measured at 490 nm using a spectrophotometer. The carbohydrate content was calculated using a formula based on the standard graph and the absorbance readings.

$$\text{True Carbohydrate (\%)} = \frac{\text{Graph factor (µg) x Optical density x Dilution factor x Total vol. (ml) x } 10^{-6}}{\text{Sample aliquot (ml) x Weight of sample (g)}} \text{ x 100} \quad \ldots(3)$$

Lycopene and β-carotene content

The lycopene content in the dehydrated sample was estimated by using the method described by Rangana (1979) with some modification. The lycopene content was estimated by extracting the dehydrated tomato powder sample with acetone and petroleum ether. The color of the diluted sample was measured at 503 nm using a spectrophotometer, and the lycopene content was calculated using a formula based on the optical density and dilution factor.

$$\text{Lycopene (mg per 100g)} = \frac{\text{3.1206 x Optical density x Volume made up x Dilution x 100}}{\text{Weight of sample (g) x 1000}} \quad \ldots(4)$$

The β-carotene content was determined with a slight modification of the method by Srivastava and Kumar (2004). The β-carotene content was determined by extracting the tomato powder sample with acetone and petroleum ether. The color of the solution was measured at 452 nm using a spectrophotometer, and the β-carotene content was calculated using a formula based on the optical density and dilution factor.

β – carotene (mg per 100g) =

$$\beta\text{- carotene (mg per 100g)} = \frac{\text{0.207 x Optical density x Dilution factor x Total vol. (ml)}}{\text{Weight of sample (g)}} \quad \ldots(5)$$

pH

The pH value of the tomato powder sample was determined using a digital pH meter that was standardized with buffer solutions before analysis.

TSS (total soluble solids)

The TSS of the tomato powder sample was determined by boiling a weighted sample in water, filtering the solution, and measuring the refractive index using a refractometer. The TSS value was corrected based on the dilution factor.

Ash

The ash percentage of the tomato powder sample was determined by ashing a weighted sample in a muffle furnace and calculating the percentage of ash based on the initial and final weights. The formula used is given below:

$$\text{Ash (\%)} = \frac{\text{Weight of sample after ashing}}{\text{Inital weight of sample}} \text{ x 100} \ldots(6)$$

Sensory evaluation

Sensory evaluation of the tomato powder samples was conducted by a panel of 10 panellists who rated the samples based on color, flavor, taste, odor, and overall acceptability using a hedonic rating test. The scores ranged from 1 (dislike extremely) to 9 (like extremely), and samples with an overall quality score of 5 or above were considered acceptable.

RESULTS AND DISCUSSION

Ascorbic acid

The ascorbic acid of tomato powder ranges between 16.68 to 37.65 mg/100g during tray drying at different temperatures, 25 to 34.56 mg/100g in sun drying, between 13.82 to 42.56 mg/100g in combination drying (Fig.1). The ascorbic acid content was higher at the 60^0C for all the samples as compared to 55 and 65^0C in tray and combination drying. This can be due to the heat sensitivity of ascorbic acid at higher temperature and also the longer duration of processing at lower temperature which is mentioned by Jorge *et al.* (2018). Among all the pre-treatment and temperature combinations, tomato slices pre-treated with 0.5% citric acid at 60^0C showed the highest value of ascorbic acid followed by 0.5% sodium metabisulphite and sodium chloride.

Protein content

The protein content of tomato powder ranges between 12.40 to 15.36 mg/100g in tray drying. The same results were found by Famurewa and Raji (2011). The protein content of tomato powder is between 19.98 to 21.76 mg/100g in sun drying, 15.43 to 20.89 mg/100g in combination drying (Fig.2). The protein content was higher at 55^{0}C for all the samples as compared to 60 and 65^{0}C in tray drying and combination drying. Among all the pre-treatment and temperature combinations, tomato slices pre-treated with 0.5% sodium chloride at 55^{0}C showed the highest value of protein followed by 0.5% sodium metabisulphite and citric acid.

Carbohydrate content

The carbohydrate content of tomato powder ranges between 65.30 to 72.93 mg/100g in tray drying, 50.68 to 53.51 mg/100g in sun drying, 52.68 to 64.67 mg/100g in combination drying (Fig.3). The carbohydrate content was higher at 55^{0}C for all the samples as compared to 60 and 65^{0}C in tray and combination drying. Among all the pre-treatment and temperature combinations, tomato slices pre-treated with 0.5% sodium chloride at 55^{0}C showed the highest value of carbohydrate content followed by 0.5% sodium metabisulphite and citric acid.

Lycopene content

The lycopene content of tomato powder ranges between 83.58 to 107.45 mg/100g in tray drying, 95.72 to 103.81 mg/100g in sun drying, 92.69 to 105.34 mg/100g in combination drying (Fig.4). The lycopene content was higher at the 60! for all the samples as compared to 55 and 65^{0}C in tray and combination drying. The similar results were obtained by Das *et al.* (2013). Among all the pre-treatment and temperature combinations, tomato slices pre-treated with 0.5% sodium chloride at 60! showed the highest value of lycopene content followed by 0.5% sodium metabisulphite and citric acid. The lesser reduction in lycopene content of SMB treated compared to CA is reported by Owureku *et al.* (2014).

β-carotene content

The β-carotene content of tomato powder ranges between 32.10 to 42.40 mg/100g in tray drying, 28.87 to 33.77 mg/100g in sun drying, 29.13 to 34.87 mg/100g in combination drying (Fig.5). The β-carotene content was higher at 55^{0}C for all the samples as compared to 60 and 65^{0}C in tray and combination drying. Among all the pre-treatment and temperature combinations, tomato slices pre-treated with 0.5% sodium chloride at 55^{0}C showed the highest value of β-carotene content followed by 0.5% sodium metabisulphite and citric acid. This could be due to reduction in thermal degradation and oxidation of compounds due to pretreatment which is mentioned by Chawafambira and Maramba (2022).

pH

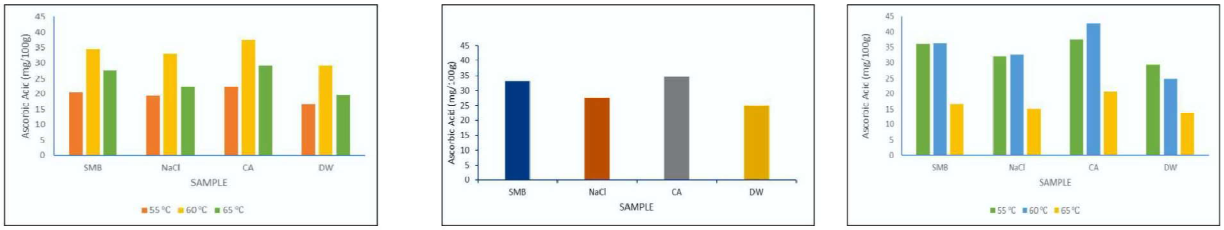
The pH of tomato powder ranges between 4.09 to 4.17 in tray drying, 4.25 to 4.30 in sun drying, 4.16 to 4.28 in combination drying (Fig.6). The pH was higher at 65^{0}C for all the samples as compared to 55 and 60^{0}C in tray and combination drying. Among all the pre-treatment and temperature combinations, tomato slices pre-treated with 0.5% sodium metabisulphite at 65^{0}C showed the highest value of pH after controlled sample and lowest was of the sample pretreated with 0.5% citric acid. This could be due to the high acidic nature of citric acid. The similar result was obtained by Chawafambira and Maramba (2022).

TSS (total soluble solids)

The TSS of tomato powder ranges between 7.64 to 8.82 in tray drying, 5.64 to 6.36 in sun drying, 6.66 to 7.64 in combination drying (Fig.7). The TSS was higher at 65^{0}C for all the samples as compared to 55 and 60^{0}C in tray and combination drying. This result is also supported by Chawafambira and Maramba (2022). Among all the pre-treatment and temperature combinations, tomato slices pre-treated with 0.5% citric acid at 65^{0}C showed the highest value of TSS followed by 0.5% sodium chloride and sodium metabisulphite.

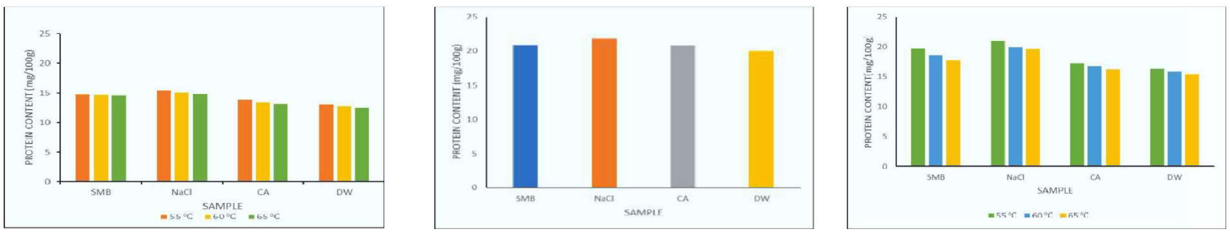
Ash content

The ash content of tomato powder ranges between



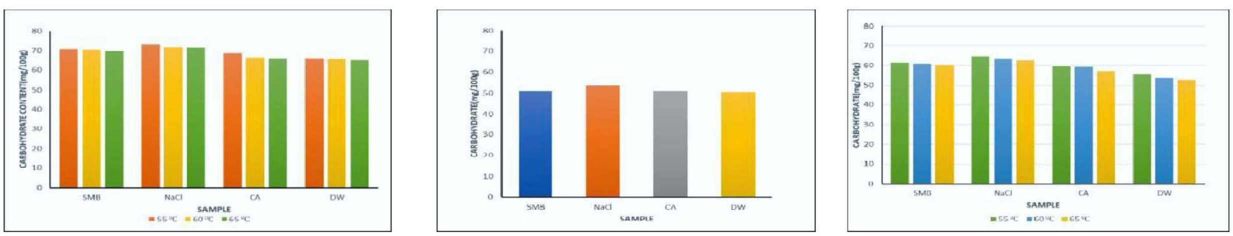
A B C

Fig. 1: Ascorbic acid content in tomato powder A. Tray dried B. Sun dried C. Combination dried



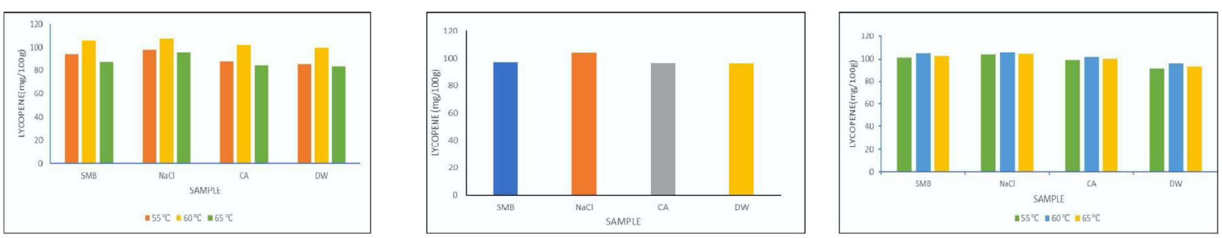
A B C

Fig. 2: Protein content in tomato powder A. Tray dried B. Sun dried C. Combination dried



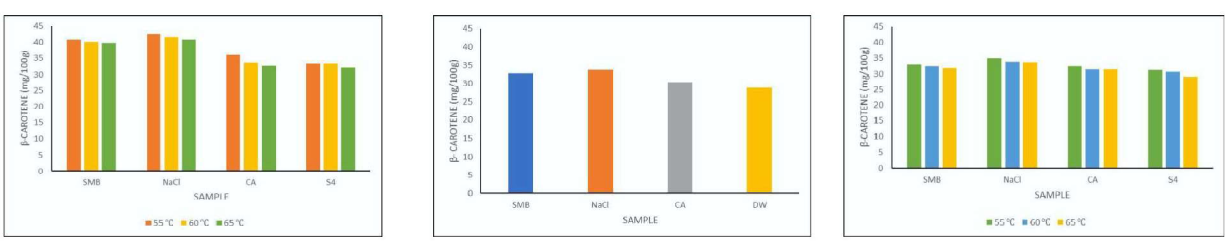
A B C

Fig. 3: Carbohydrate content in tomato powder A. Tray dried B. Sun dried C. Combination dried



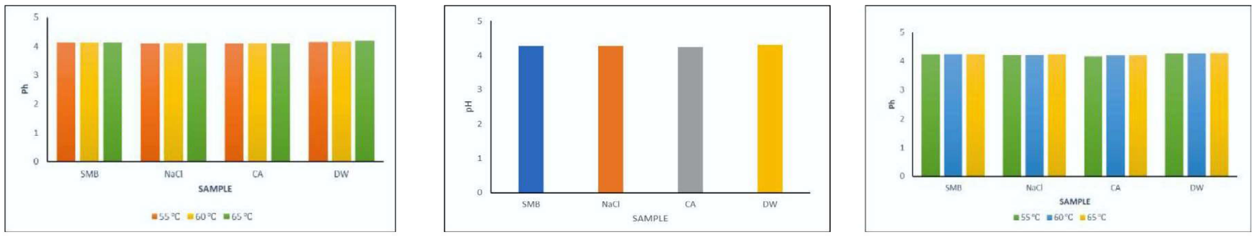
A B C

Fig. 4: Lycopene content in tomato powder A. Tray dried B. Sun dried C. Combination dried



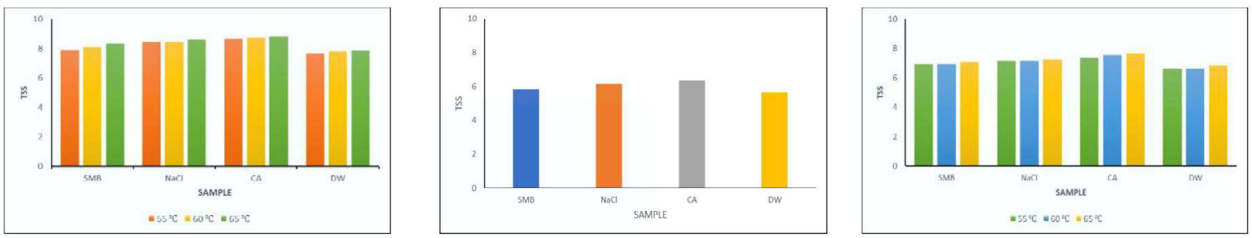
A B C

Fig. 5: β-carotene content in tomato powder A. Tray dried B. Sun dried C. Combination dried



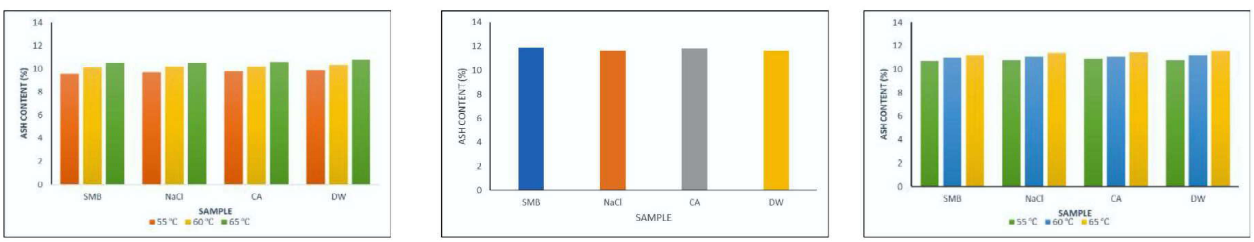
A B C

Fig. 6: pH in tomato powder A. Tray dried B. Sun dried C. Combination dried



A B C

Fig. 7: TSS in tomato powder A. Tray dried B. Sun dried C. Combination dried



A B C

Fig. 8: Ash content in tomato powder A. Tray dried B. Sun dried C. Combination dried

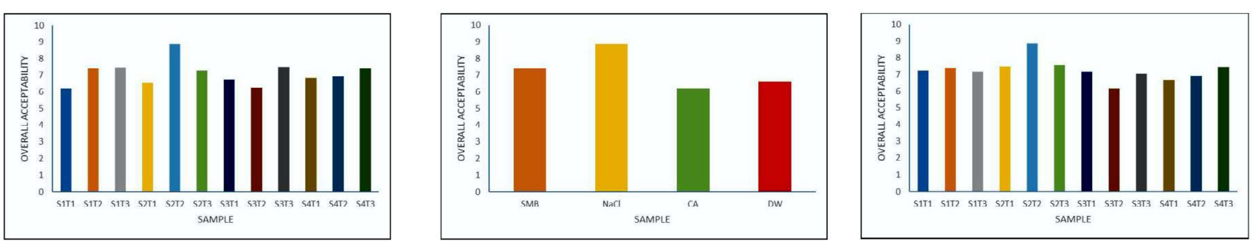


Fig. 9: Sensory evaluation of tomato powder A. Tray dried B. Sun dried C. Combination dried

9.60 to 10.80 % in tray drying. The similar results were obtained by Surendar *et al.* (2018). The ash content of tomato powder is between 11.63 to 11.90%, 10.70 to 11.60% in sun drying and combination drying (Fig.8). The ash content was higher at 65! for all the samples as compared to 55 and 60! in tray and combination drying. Among all the pre-treatment and temperature combinations, tomato slices pre-treated with 0.5% citric acid at 65! showed the highest value of ash content after controlled samples.

Sensory evaluation

The sensory score ranges from 0 to 9. The excellent sample was given a score 9 and very bad was given as 0. The sensory test contains the analysis of samples on the basis of color, taste, aroma and overall acceptability. The sensory score varied from 6.2 to 8.85 in tray drying, 6.2 to 8.85 in sun drying and 6.17 to 8.85 in combination drying (Fig.9). The maximum overall acceptability obtained for Sodium chloride pretreated sample.

CONCLUSION

A study investigated the impact of different pre-treatments and drying methods (tray, sun, combination) on physiochemical properties of dried tomato powder. Pre-treatment with citric acid, sodium metabisulphite, and sodium chloride had a positive effect on properties compared to the control. The highest ascorbic acid content was found in tomato slices pre-treated with 0.5% citric acid at 60!. Protein, carbohydrate, β-carotene, and lycopene content were higher in pre-treated samples. Tomato slices pre-treated with 0.5% sodium chloride at 55! had the highest protein content. pH and TSS varied based on pre-treatment and drying. Tomato slices pre-treated with 0.5% citric acid at 65! showed the highest pH and TSS. Ash content was higher in control samples. Tomato slices pre-treated with 0.5% citric acid at 65! showed the highest ash content. Sensory evaluation showed sodium chloride pre-treatment had the highest acceptability. In conclusion, pre-treatment with citric acid, sodium metabisulphite, and sodium chloride, combined with specific drying methods and temperatures, positively influenced the physiochemical parameters of dried tomato powder. This can optimize the drying process and improve dried tomato product quality. The optimized drying conditions for each drying are given below:

Drying	Temperature	Pretreatment
Tray drying	60^0C	0.5% Sodium Chloride
Sun drying	-	0.5% Sodium Chloride
Combination drying	60^0C	0.5% Sodium Chloride

REFERENCES

Chamoun, L., Karboune, S., Lutterodt, H. E., and Melgar Quinonez, H. (2023). Nutritional composition and consumer acceptance of tomato paste fortified with palm weevil larvae (Rhynchophorus phoenicis Fabricius) in the Ashanti region, Ghana. *Food Science and Nutrition*. 11, 4583-4595.

Choudhury, B. (1978). Vegetable Production in India. *Symposium on Vegetable growing in the Asian and Pacific Region, XX IHC 101*, Pp 47-54.

Chawafambira, A. and Maramba, B. B. (2022). Use of sodium metabisulphite and citric acid to control the degradation of nutraceutical compounds in dried tomato powder during prolonged storage. *Journal of Food Processing and Preservation*, 46(1): 16149.

Das Purkayastha, M., Nath, A., Deka, B. C. and Mahanta, C. L. (2013). Thin layer drying of tomato slices. *Journal of Food Science and Technology*, 50 (4): 642-653.

Dubois, M., Gilles, K., Hamilton, J., Rebers, P. and Smith, F. (1956). Colorimetric method for determination of sugars and related substances. *Analytical Chemistry*, 28(3): 350-356.

Famurewa, J. A. V., and Raji, A. O. (2011). Physicochemical characteristics of osmotically dehydrated tomato (Lycopersicon esculentum) under different common drying methods. *International Journal of Biological and Chemical Sciences*. 5(3), 1304-1309.

Jorge, A., Sauer Leal, E., Sequinel, R., Sequinel, T., Kubaski, E. T., and Tebcherani, S. M. (2018). Changes in the composition of tomato powder (*Lycopersicon esculentum* Mill) resulting from different drying methods. *Journal of Food Processing and Preservation*, 42(5): 13595.

Lowry, O. H., Rosebrough, N. J., Farr, A. L., and Randall, R. J. (1951) Protein measurement with the Folin phenol reagent. *J. Biol. Chem.,* 193: 265–275.

Owureku Asare,M., Agyei Amponsah, J.,Saalia, F. K., Alfaro, L., Espinoza, L., and Sathivel, S. (2014). Effect of pre- treatment on physicochemical quality characteristics of a dried tomato (*Lycopersicon esculentum*). *African Journal of Food*

Science, 8(5): 253– 259.

Ranganna, S. (1986). Handbook of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill, New Delhi.

Ranganna, S. (1979). Manual of Analysis of Fruit and Vegetable Products. McGraw-Hill Publishing Company Limited, New Delhi.

Srivastava, R.P. and Kumar, S. (2004). Fruits and Vegetables Preservation Principles and Practices (3rd ed.) N. Y. USA, Oxford and IBH Publishers.

Surendar, J., Shere, D. M. and Shere, P. D. (2018). Effect of drying on quality characteristics of dried tomato powder. *Journal of Pharmacognosy and Phytochemistry*, 7(2): 2690-2694.

Received: August 3, 2023
Accepted: August 19, 2023