

Effect of Tray Drying on Antioxidant, Total Phenols and Total Flavonoid Content of Red Skinned Onion

Sonia Morya¹, Arno Nuemann², Promila Godara¹, Sharvary Arun Vichare¹, Rajesh Venkata Vaddi¹, Sahithi Rajaboina¹, Varsha Kothapally¹, Tanushree Das¹, Yashdeep Rao¹, Ashar K Muhammed¹ and Vinod Kumar¹

¹Department of Food Technology and Nutrition, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

²BET Bioscience Extraction Technologies Inc., Abbotsford, Canada

*Correspondence to:

Sonia Morya
Department of Food Technology and Nutrition,
School of Agriculture,
Lovely Professional University,
Phagwara, Punjab, India.
E-mail: sonia.morya8911@gmail.com

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Abstract

The onion holds significant importance as a key ingredient in nearly all types of dishes. Adding onions not only improves the taste, but also, they have some medicinal, anti-inflammatory, and anti-microbial characteristics. Various forms of dehydrated onions are available, such as flaked, minced, chopped, and powdered. These products hold considerable value and play a significant role in the worldwide trading arena. Moreover, the onion plant is extensively utilized as a flavoring element in a diverse range of food creations, including minced meats, sauces, soups, and salad dressings. Drying the plant material serves to lower the moisture content of the product to an appropriate level for storage, while also leading to the diminishment of flavor, taste, color, and nutritional elements. Mainly dried onions have the more content of flavonoids, phenols and antioxidants than fresh onions. There are many ways to dry the onions such as sun drying, microwave drying, tray drying. This study is aimed to assess the quantities of flavonoids, phenols, and antioxidant properties in tray dried onions. Slices of red onions underwent drying on a tray dryer set at 60 °C for a duration of 6 h. The present study proves the effect of drying at 60 °C to reduce the moisture content to 11.50%. The assessment of antioxidant effectiveness was carried out using the DPPH assay, while quantification of overall phenolic and flavonoid contents was determined through the Folin-Ciocalteu (FC) and aluminum chloride methods, respectively. The findings indicated that the total carotenoid content and the total phenolic content were estimated at 0.11 g/100 g and 528.89 mgGAE/100 g respectively. The total concentration rose from 9.78 mg/100 g (control) to 159.56 mg/100 g capable of demonstrating 14.23% antioxidant potential. Further analysis from Fourier Transform Infrared (FTIR), colorimetry as well as the thermal degradation of the red onion showed that the concentration of total phenols, flavonoids, and antioxidants was highest at the temperature of 60 °C compared to other temperatures. These findings suggest that tray drying can be an effective method for enhancing the antioxidant properties of red onions.

Keywords

Red onion, Tray dryer, Phenolic compounds, Good health, Well-being

Introduction

The onion (*Allium cepa*) holds a prominent position as one of the extensively grown vegetables globally and serves as a rich reservoir of flavonoids. Hailing from the Allium family, this versatile vegetable is cherished worldwide, valued not only for its flavor but also for its noteworthy contribution as a substantial supplier of numerous advantageous compounds [1]. Alliums are recognized for displaying antibacterial and antifungal characteristics, housing potent antioxidants, sulphur, and an array of diverse phenolic compounds [2]. The bioactive

constituents present in red onion skin, notably phenolics and flavonoids, offer the potential for generating enhanced-value products [1]. Onions contain bioactive elements known as flavonoids, which contribute a unique taste and scent and hold promising health advantages. The primary flavonoid found in onions is quercetin, which has been associated with numerous health benefits such as anti-inflammatory, anti-cancer and cardiovascular protective qualities [3]. A significant portion of these flavonoids was depleted during initial preparation stages, involving peeling, trimming, and dicing, carried out prior to blanching. After blanching, the edible portion of the onion contained 25 mg of quercetin. Onions in prepared foods and home cooked foods may be an excellent source of flavonoids [3]. The levels of separated phenolic compounds and quercetin within onion skin were roughly three to five times greater than those found in the onion's edible part. Extracts from onion skin exhibited noteworthy antioxidant potency. Among plant-based materials like vegetables, fruits and grains, phenolic compounds play a pivotal role in furnishing antioxidant activity. Red onions displayed the highest overall phenol content. The effectiveness of these compounds in terms of antioxidant activity is partly attributed to their capacity for one-electron reduction potential, which involves their ability to serve as a source of hydrogen or electrons [4]. Research has been conducted to examine the antioxidant, phenolic, and flavonoid levels present in red onions.

For the investigation, a recently harvested variety of available onion (cultivar Bhima super) has been chosen and brought from the farmer's field at Lovely Professional University. The onions were stored in the dark at 5 - 8 °C until utilized for analysis. This research fills a vacuum in the literature by providing a targeted approach to improving the phytochemical profile of red skinned onions. The novelty of this study is its detailed investigation of the effects of tray drying on the phytochemical composition of red skinned onions, a commonly consumed vegetable with significant health benefits. Previous studies may have concentrated on general drying methods or different types of onions, but this research specifically quantifies the changes in antioxidant activity, total phenols, and total flavonoid content across various drying temperatures. The discovery of 60 °C as the ideal drying temperature for enhancing these compounds for the sole reason for concentrating and preserving the valuable bioactive compounds in red skinned onion for industrial and drying applications. Finally, the study provides a useful and accurate guideline for maximizing the nutritional and health benefits of red skinned onions.

Materials and Methods

Materials

Medium-sized red onions (*A. cepa* L.), weighing between 50 - 100 g were acquired from a local farmer's field at Lovely Professional University in January 2023. Red onions were chosen over other onion cultivars because of their high phenolic and flavonoid content. Their vivid hue suggests a high concentration of these substances, which makes them a perfect subject for researching how drying affects phytochemical preservation. To guarantee uniformity in the drying process, onions with a certain weight range (100 - 150 g) and diameter (5 - 7

cm) were selected. Size and weight uniformity promotes even heat exposure and reduces variation in drying rates, resulting in more consistent and dependable outcomes. We used only mature, premium onions that had no evident flaws, diseases, or damage. This guarantees a high baseline concentration of phytochemicals and antioxidants in the beginning material, facilitating a more accurate evaluation of the effects of the drying process.

The onions were transported to our laboratory in plastic bags for analytical assessment. The selection of onion samples was guided by uniform shape and color. The onion samples were kept under regular atmospheric conditions until subsequent analysis took place. The research was carried out within the Department of Food Technology and Nutrition at Lovely Professional University, Punjab, India.

Drying

The onions underwent peeling, washing, and slicing into slices approximately 4 ± 1 mm thick. The drying process employed was tray drying. This method controls the heating, airflow, and humidity. The sliced onions of 1 kg were equally spread out on a stainless-steel tray that measured 32 cm by 23 cm by 3 cm. The tray drier was set to a temperature of 60 °C. We studied the tests at this temperature since a prior study found that 60 °C is the ideal range of temperature for drying fruits and vegetables. Based on early research and previously published works, the temperature of 60 °C was chosen because moderate temperatures efficiently store phytochemicals while limiting heat degradation. Sensitive substances may break down at higher temperatures, while moisture may not be completely removed at lower temperatures, increasing the danger of microbial development and spoiling. By preserving the integrity of flavonoids, phenols, and antioxidants, 60 °C creates a balance. In order to achieve complete dehydration, which is essential for prolonging shelf life and avoiding microbiological contamination, a drying time of six h was selected. This time frame is ideal for reaching the right moisture content without overexposure to heat, which could cause delicate phytochemicals to break down.

In a study on onion powder drying, the powder was dried at 60 °C after 30 min of tray drying. Certain restrictions apply. One onion variety, three temperature settings, and onion slice cuts.

Cleaning, peeling, slicing, and blanching onions were done. Drying the onion slices was conducted using a tray dryer. The slices were packed in low density polyethylene bags after being dried, then sieved through 32 mesh screens and ground in a grinder. There are instructions provided for using some of the tools, glasses, and chemicals used throughout the study. 1. Digital balance for weighing things; 2. Slicer; 3. Tray dryer; 4. Desiccant; 5. Hot plate; and 6. Sealing machine.

Quality analysis of onion powder

Moisture test

Moisture content analysis for each powder sample involved placing 3 g of the sample in a hot air oven at 105 °C for a duration of 3 h, followed by calculation of the weight variation. The experimentation was conducted in triplicates.

Ash content

For the analysis of ash content, precisely 1 g of the sample was weighed. The powders were meticulously blended after being finely ground. The samples underwent a 5 h incineration process in a muffle furnace, maintained at a temperature of 550 ± 25 °C. Subsequently, the samples were moved to desiccators and allowed to cool for half an hour. They were then weighed until two consecutive weight measurements exhibited a variance within 0.5 mg.

FTIR spectroscopy

Onion powder samples were analyzed through FTIR spectroscopy using an FTIR device (Perkin Elmer). The functionality of the instrument and the handling of data processing were overseen using spectrum 10 software. For FTIR analysis, a tiny quantity of pasted powder samples was formed into pellets using potassium bromide (KBr), and a thin film was created by applying pressure. The information on infrared transmittance was gathered using wave numbers 8300 to 350 cm^{-1} . With simple KBr pellets serving as the control, all samples were examined in triplicate. The identification of the sample's functional groups was achieved by comparing the spectral data with a reference.

Differential scanning calorimetry (DSC)

Using a Perkin Elmer instrument, DSC measurements were made on the onion powder to ascertain the phase transition and/or decomposition temperature (Td). Using nitrogen as the medium, the onion powder underwent DSC analysis at heating rates ranging from 0.01 °C/min. The examination involved cooking the powder samples in an aluminum pan within a temperature range of -70 °C to + 450 °C, with an aluminum lid featuring three small perforations. The sample mass in dry form was about 5 mg. The comparison also featured an empty crucible. The measurements were done three times for each type of sample.

Thermogravimetric analysis (TGA)

TGA is a thermal testing technique in which the sample is subjected to constant change in temperature on time. This test was done to induce the thermal reaction which lets us know the change in mass or weight which later helps to observe and analysis. The sample undergoes heating in either nitrogen or air, starting from room temperature and reaching 1000 degrees. Following this, the reduction in weight is quantified, which arises from various factors like semi-volatile chemicals, polymer degradation, ash content, carbon black, and moisture. This analysis allows for the differentiation of losses caused by surface-absorbed solvents from those due to degradation, as well as solvents present within the crystal lattice. Each stage is noted with a weight of the sample and Y axis with, X axis with temperature makes the "TGA thermal graph". This analysis technique aim is to characterize the materials by measuring their mass change with temperature as the function.

Carotenoid content

The procedure for extracting carotenoids from heated onion samples followed the methods outlined by Silva da Rocha

et al. [5]. Initially, 2 g of finely ground onion were mixed with 25 cm^3 of acetone. The mixture was vigorously mixed using a vortex for a duration of 10 min, then filtered through filter paper (Whatman grade 1). The resulting filtrate was separated using a separation funnel, and 20 ml of petroleum ether were used to fractionate it. Subsequently, the onion samples underwent a washing process to remove acetone, achieved by rising with 100 ml of distilled water. After repeating these steps, an additional filtration was carried out using Whatman grade 1 filter paper coated with anhydrous sodium sulphate (5 g) to eliminate any remaining water. This filtered the petroleum ether layer as well. With the addition of petroleum ether, a final extract volume of 25 ml was obtained. To measure the absorbance of the red onion samples, a wavelength of 450 nm was used, following the procedures.

Total phenolic content

Phenolic compounds have the potential to be efficient antioxidants that stop cell damage brought on by the processes of free-radical oxidation, which can result in cancer and other disorders [6]. They can be divided into five main groups: phenolic acids (hydroxycinnamic and hydroxybenzoic acids), stilbenes, quinones, flavonoids (anthocyanins and anthocyanidins, flavanols, flavones, and isoflavones), and tannins and lignans [7]. The quantification of total phenolic compounds in onion extracts was conducted using the FC reagent, following the method outlined by Yoo et al. [8], with slight adjustments to their procedures. After introducing 10 ml of a 7.5% Na_2CO_3 solution, 1 ml of FC reagent was added to the mixture and agitated for 5 min. The solution within the tubes was subsequently mixed again, and the final volume was adjusted to 25 ml using deionized water. The assessment of total phenolic content was carried out after 1 h using a spectrophotometer (Shimadzu-Japan), with a wavelength of 750 nm. Gallic acid (from 0 to 200 mg/ml concentration) was employed as the standard to create a calibration curve. All measurements were performed in triplicate. The results are presented in mg of gallic acid equivalent (GAE) per 100 g of fresh weight.

Total flavonoid content

The quantification of total flavonoid content in onion extracts was accomplished using the colorimetric technique detailed by Hogan et al. [9]. A volume of 1 ml of the extract was mixed with 0.3 ml of NaNO_2 , 0.3 ml of AlCl_3 , and 2 ml of NaOH. Subsequently, the absorbance of the resulting mixture was measured at 510 nm using a spectrophotometer. The reported outcomes are expressed in mg of catechin (CA)/100 g of fresh weight.

Antioxidant activity

The assessment of free radical scavenging activity in red onion samples was conducted employing DPPH (1,1-diphenyl-2-picrylhydrazyl). The extract was combined with 2 ml of a methanolic solution containing DPPH. This mixture was vigorously agitated and left to stand at room temperature for a duration of 30 min. Subsequently, the absorbance at 517 nm was measured using a spectrophotometer. All measurements were carried out in triplicate.

Results and Discussion

Effect of drying temperature on moisture content

The moisture content of red onions in the control group was determined to be 87.32%. In comparison to the control group, the onion sample tray dried at 60 °C had significantly low moisture contents. While the red onions' respective moisture contents when tray dried at 60 °C was found to be 11.50%.

Total carotenoid content

The control onion samples exhibited a total carotenoid content of 0.02 g/g (red). Red onions were shown to have a total carotenoid concentration of 0.11 g/100 g fresh weight when dried in tray drier at 60 °C.

Impact of drying temperature on phenolic content

The onion samples from the control group were discovered to possess a total phenol content of 64.35 mgGAE/100 g (red). Red onions' overall phenolic content increased after drying. Red onions exhibited a total phenolic content of 64.35 mgGAE/100 g at room temperature, 528.89 mgGAE/100 g at 60 °C. To optimize tray drying at 60 °C, high enhancement in both total phenolic and total flavonoid content was identified. Depending on the dehydration temperatures, numerous variations in the contents of phenolic constituents were detected in comparison to the literature.

Changes in flavonoid content due to drying

The onion bulb's quercetin conjugates, according to Makris and Rossiter [10], were resistant to heat deterioration. According to several earlier research, when onions were heated to specific temperatures, the bioactive chemicals within the plant matrix were liberated from their conjugated forms [11]. After the drying process, the onion samples exhibited an elevated total flavonoid content. Specifically, the total flavonoid concentration in red onions rose from 9.78 mg/100 g (control) to 159.56 mg/100 g, following drying at 60 °C respectively. Substantial enhancements in total phenolic and total flavonoid contents for both white and red onions were achieved through the drying process at 60 °C.

Effect of drying on antioxidant activity

Upon drying the onion samples, there was a subsequent elevation in antioxidant activity values, as evidenced by increased DPPH scavenging. Red onion samples' antioxidant activity ratings and their total phenolic contents showed a linear relationship. The observed increase in the total phenol and flavonoid levels of the onion samples is likely attributed to the preservation of phenolic components, which were not subjected to desiccation at the specified drying temperatures.

Red skinned onions were found with 39% total phenols, as well as 14.23% antioxidant activity levels, according to Lachman et al. [12]. Onion genotypes, varying temperatures, growth circumstances, climatic and ecological variables, as well as some analytical settings and the types of solvents employed, can all contribute to these variances (Table 1).

Table 1: Comparison of the various chemical constituents of red skinned onion after drying.

Analysis	Treatment	Control	Sample
Moisture content	Drying at 60 °C	87.32%	11.50%
Carotenoid content		0.02 g/g	0.11 g/100 g
Phenolic content		64.35 mg GAE/100 g	528.89 mg GAE/100 g
Flavonoid content		9.78 mg/100 g	159.56 mg/100 g
Antioxidant activity		12.29%	14.23%

Utilizing FTIR spectroscopy for characterization and functional group identification

FTIR is an excellent tool to understand the valuable content of characterization and to identify the functional groups (chemical bonds) present in a mixture of food material samples. The present study of FTIR (Figure 1) indicates the presence of amide group (alcohol) 3272.11 cm⁻¹, amine group (alcohol) 3303.50 cm⁻¹, alkene group 1623.48 cm⁻¹, aromatic group 1406.49 cm⁻¹, alkyl halide 1043.47 cm⁻¹, and alkyl halide (C-Br) 527.66 cm⁻¹. Table 2 presents data concerning red onion slices that were subjected to oven drying at 60 °C, detailing their moisture content and bioactive characteristics. The presence of polymeric hydroxyl groups, aromatic compounds, phenols, and peak confirm the existence of polyphenols, namely phenolic and flavonoids compounds, which are responsible for red onion antioxidant properties.

Understanding sample physical properties using differential scanning calorimeter

The DSC is one of the best methods to attain information of the sample physical properties which tend to change at different temperatures regardless of time. As the temperature ranges from -150 °C to 700 °C. This analysis lets us know the temperature at which the sample changes from amorphous

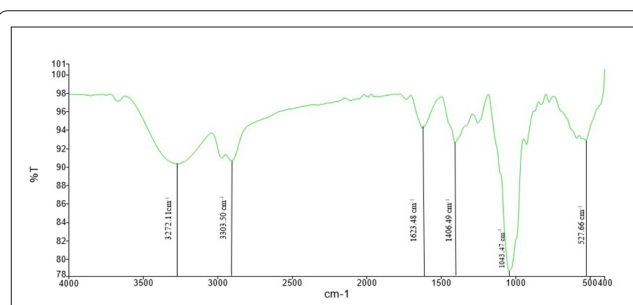


Figure 1: FTIR spectra of red skinned onion.

Table 2: Fourier transform infrared peaks and functional groups of red onion powder.

Peak values	Functional groups
3272.11	O-H and N-H stretches (alcohol group) amide
3303.50	O-H and N-H stretches (alcohol group) amine
1623.48	C=C stretches (alkene group)
1406.49	C=C and aromatic ring C-H wags (aromatic group)
1043.47	C-F (alkyl halide)
527.66	C-Br (alkyl halide)

solid form to crystalline solid form. The present study of DSC (Figure 2) indicates the onset temperature of 148.34 °C forms crystalline peak at 155.48 °C, got hold at 169.54 °C which later moves to onset temperature 204.61 °C and forms crystalline at 218.35 °C and end at 249.52 °C.

Extracting thermal property using TGA

The TGA is the method used to extract data of the sample thermal properties which changes on the increase and decrease of the temperature. The temperature range of TGA is from 25 °C to 600 °C and amount of sample from 2 - 10 gm at heating rate of 10 °C/min. As we can observe, the thermal degradation of the red onion sample started at 95 °C (Figure 3).

Conclusion

The present study is concluded that the overall phenolic and flavonoid content in red onions (Bhima red) increases as an increase in temperature occurs. Tray drying of onions is a little bit time consuming but still maintains the phenolic contents better. Tray dried onion powder increases shelf life of up to 4 months. In multi-layered packaging, products like powder can be created and stored for longer than 60 days with less microbial burden. A quantitative study was conducted to assess the impact of drying on various attributes of red onions, including total phenols, total flavonoids, carotenoid levels, antioxidant activity, and phenolic compounds. This study was carried out at 60 °C. The current study demonstrates how heating to 60 °C can lower the moisture content to 11.50%. The DPPH assay was utilized to evaluate the efficacy of antioxidants, and the FC and aluminum chloride procedures were employed to quantify the total phenolic and flavonoid contents, respectively. According to the results, the estimated values for the total phenolic content and the total carotenoid content were 528.89 mgGAE/100 g and 0.11 g/100 g, respectively. From 9.78 mg/100 g (control) to 159.56 mg/100 g, the total concentration increased and showed 14.23% antioxidant potential. In comparison to other temperatures, the concentration of total phenols, flavonoids, and antioxidants was maximum at 60 °C, according to additional data from FTIR, colorimetry, and the thermal degradation of the red onion. The results of this study show tray drying at 60 °C as an efficient way to increase the nutritional content of red onions, with important practical implications for food processing and storage. Through the preservation and enhancement of antioxidant activity, total phenols, and flavonoid content, this technique can yield nutritious dried onions that are perfect for the market for functional foods. This strategy can add value to the finished product by satisfying the needs of health-conscious consumers looking for nutrient-rich ingredients.

The longer shelf life of tray-dried onions, which comes from their lower moisture content, is a big benefit for food manufacturers. Because onions are lightweight and small, this increases their useful life in a variety of culinary applications, improves storage efficiency, and lowers transportation costs. In multi-layered packaging, products like powder can be created and stored for longer than 60 days with less microbial burden. The study reveals that the dried onion powder has numerous phenolic and bio-actives hence capacity on consumption can

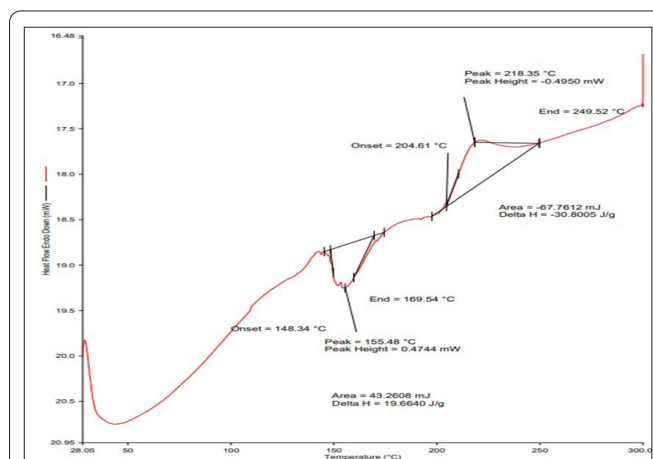


Figure 2: DSC results of red skinned onion.

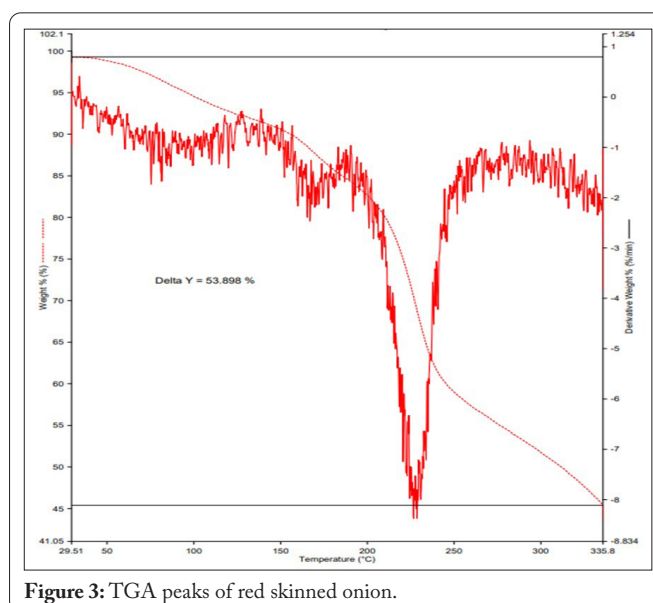


Figure 3: TGA peaks of red skinned onion.

help to reduce many health problems. Thus, one can conclude the dried red onion powder helps to achieve good health and well-being of the host.

Future Prospects

Tray drying is an essential technique for preserving the nutritional value of red onions. Therefore, it would be beneficial for the food business as well as consumers to work together to maximize the benefits of this preservation approach. Careful temperature management during the drying process is a fundamental advice for the food sector. To preserve the delicate balance of antioxidants, phenols, and flavonoids in onions and to ensure maximum retention of their health-promoting characteristics, it is essential to keep them at a consistent temperature of approximately 60 °C. Purchasing cutting-edge drying apparatus with accurate temperature control mechanisms can be crucial to reaching this goal. Pre-treatment procedures, like blanching onions before drying them, should also be incorporated into production procedures. Blanching helps to maintain the color, texture, and nutritional value of onions while also stopping enzymatic deterioration. In addition, the application of antioxidant soaks, like ascorbic acid solutions,

can strengthen the onions' antioxidant potential during the drying process, enhancing the preservation of essential phytochemicals. Another important factor to consider is uniformity in slicing, since this promotes equal drying and eliminates variations in the nutritional value of individual onion pieces. Additionally, it is crucial for the business and consumers to choose moisture-proof packaging while storing tray-dried onions in order to prevent microbial deterioration and rehydration. In order to improve our understanding of tray drying and maintain the nutritional content of red onions, there are a number of interesting areas that need to be investigated in the future. One such path is tray-dried onions' sensory qualities, which have received less attention than their nutritional profile. Examining the taste, texture, and aroma of tray-dried onions can reveal important information about their acceptability by consumers and help develop methods for improving their palatability. Studies on the stability of long-term storage are also necessary to determine how long-lasting and resilient tray-dried onions are. Evaluating alterations in phytochemical content, sensory attributes, and overall quality over extended periods of storage can provide vital information for optimizing storage procedures and extending product shelf life. Additionally, studying the phytochemicals' bioavailability after drying offers a potential way to clarify how long these substances are still available for the body to absorb and use. We can keep improving and optimizing tray drying as a powerful instrument for maintaining the nutritional integrity of red onions by investigating these and other research avenues, which will ultimately advance the fields of food preservation and public health.

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Conflict of Interest

None.

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