The Quality of Banana Rings (Musa acuminata, Musa spp.) Pretreated and Dried by Air Fryer

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Abstract

The primary objective in this study is to examine the impact of pretreatments (sodium metabisulphate-SO_2) and the air drying procedure on the quality of desiccated banana rings. A second objective was to ascertain the mineral content (Fe, Zn, and Cu), color characteristics, rehydration properties, and bioactive compounds (vitamin C, total phenol, total chlorophylls, total carotenoids, and antioxidant activity) in untreated and treated sodium metabisulfite (SO_2) air-dried banana rings. The findings indicate that the rehydration characteristics of untreated and SO_2-treated air-dried banana rings were not influenced by the pretreatment with SO_2. Additionally, the results indicate that the rehydration characteristics of pretreatment-air-dried banana rings were unchanged. Nevertheless, the SO_2-treated air-dried banana rings sample exhibited significantly higher levels of all mineral elements (Fe, Zn, and Cu) than the fresh and untreated air-dried banana rings sample. The pretreatment banana rings with SO_2 exhibited the best and lesser color values (a* and BI) as non-enzymatic browning when contrasted with the untreated desiccated banana rings sample. Samples of air-dried banana rings treated with SO_2 exhibited elevated levels of total chlorophyll, total carotenoids, total phenol, and vitamin C when contrasted with fresh samples. Vitamin C acid is chemically unstable due to its ability to be deactivated by a variety of oxidizing agents and its status as a potent reducing agent. The findings indicated that the highest quality product was achieved when banana ring samples were pretreated with Sodium metbisulfite (SO_2) prior to air drying.

1. Introduction

The global food industry has a strong commercial demand for the banana rings *(Musa acuminata, Musa spp.)* variation Lamuyo because of its taste, coloring, and aromatic qualities. Hot air drying is a popular method for producing dehydrated banana rings because it enables quick and large-scale processing; nevertheless, maintaining the nutritional value and commercial quality of these banana rings during the process has previously caused some major issues. According to certain research referenced in the literature, drying conditions have an impact on the dehydrated product's quality attributes **(**Carbonell et al., 1986; Simal et al., 2005). The final product's color and texture quality are significantly reduced when banana rings are dried conventionally.

Because of their high level of sensory acceptability, bananas are among the most popular fruits in the world. These seasonal fruits have a high water activity and a limited shelf life. Ripe bananas have an 80% moisture content, which makes them highly prone to degradation and results in large losses after harvest. The goal of banana processing is to reduce waste and create new goods **(Amini et al., 2019)**. Drying is a strategy process to reduce postharvest losses **(**Abe-Inge et al., 2018). In addition to limiting damage and stopping microbial growth, the drying process lowers a food's moisture content to a level that allows for safe storage for a long period of time **(**Doymaz, 2011**)**.

According to Zielinska and Markowski (2016**) and** Amit et al. (2017), the dehydration process lowers packing, storage, handling, and transportation costs, extends shelf life, enhances the sustainability of food items' nutritious components, and may even make some crops available outside of the growing season. Furthermore, market-rejected fruit can be processed into dried goods, reducing food waste and producing a popular fruit-derived product (Testa et al., 2023).

Food dehydration, broadly speaking, is the process of removing moisture from a food item. There are numerous goals for food product dehydration. The most obvious method of food preservation is dehydration. Limiting microbial growth or other reactions is made feasible by the dehydration process, which lowers the product's moisture level. This procedure allows for the preservation of the food's flavor and nutritional qualities in addition to its microbiological preservation. Significant product volume reduction is another evident goal of dehydration, as this enhances food product storage and transit efficiency (Heldman, 1975; **Chung and** Chang, 1982).

Prior research on banana drying has mostly concentrated on atmospheric drying, with air-drying being the most often utilized technique. With this approach, mass and heat transmission happen at the same time. A food's water content can be eliminated during drying through two different processes: internal water migration and external moisture evaporation. Banana drying kinetics have been explained by the former, which is thought to be the most frequent moisture migration during drying (Garcia, 1988; Mowlah et al., 1983; Sankat et al., 1996).

One of the earliest preservation techniques that humans have discovered is drying, which dates back to the prehistoric era. Dried foods are a significant part of the food supply chain in today's market. According to estimates, fruits and vegetables make up around 1% of the food industry's overall drying process, with grains being the most significant component. This process's primary goal is to reduce the water content in order to prevent or delay microbial food deterioration. Water was extracted from fruits using the sun, wind, and a smoky fire throughout history.

The technique of eliminating water from food by passing hot air through it, which stops germs and enzymes from growing, is known as air drying. Foods that have been air dried are delicious, nourishing, portable, simple to prepare, and convenient to use and store. Drying has very little effect on food's nutritional content. While pre-treating foods with sodium meta bisulfite (SO_2) enhances the amount of vitamin C, exposure to ambient heat destroys vitamin C. Dried fruits and vegetables are a healthy dietary option because they are low in fat and high in fiber and carbs **(Naseer et al., 2013)**.

Water transport within banana chunks during air drying can be compared to molecular diffusion in a liquid solution, according to Mowlah et al. (1983).

The surface color of the banana rings is a crucial requirement since undesirable color variations could result in a decline in their quality and marketing value. Carotenoids undergo autoxidation, which results in a loss of red color. It has been demonstrated that the drying circumstances affect the stability of the primary carotenoids in banana rings during storage, with the rate of deterioration rising with drying temperature (Carbonell et al., 1986; Doymaz and Pala, 2002). By preventing loss in color, vitamins, and texture, weak chemical treatments, such as applying antioxidants and calcium salts to the banana rings before drying, have improved the acceptability of finished products (Turhan et al., 1997). In addition to carotenoids, which are naturally occurring antioxidants, banana rings also include ascorbic acid and other substances.

In order to be consumed in prepared foods like pizzas, casseroles, soups, stews, and other dishes, dehydrated banana rings need to be rehydrated. The structure and composition of plant tissues may alter as a result of pretreatment, drying, and rehydration (Lewicki, 1998), which may have an impact on the organoleptic characteristics of the rehydrated banana rings. Choosing the right drying conditions is crucial for reducing heat stress and preserving the properties of important chemicals in the rehydrated product.

Benefits of the new air drying techniques should include reduced energy use, excellent quality at a fair price, and reduced CO_2 emissions with a smaller environmental impact. The food being dried, its quality, energy usage, and drying time are some of the variables that influence the drying methods chosen. These drying techniques aim to provide food items with exceptional attributes. Industrial drying is an expensive and energy-intensive operation, despite the fact that numerous drying machines have been developed and tested in the food business (Nemzer et al., 2018).

Air drying so seems to be the most effective alternative method. It is also cost-effective, sustainable, and efficient. It also lessens dependency on fossil fuels and their adverse environmental impacts (Varalakshmi 2016 **and** Nabnean et al., 2016). However, air drying may cause the finished product's bulk density and rehydration capability to decrease, as well as its flavor, color, nutrients, and antioxidant activity (Soomro et al., 2020). The phytochemical composition of fresh plant tissues may vary significantly as a result of enzymatic and non-enzymatic reactions that may take place during drying (Capecka et al., 2005). To reduce adverse changes during drying, a number of pretreatments have been used (Soomro et al., 2020; Abano et al., 2013; **and** Deori et al., 2020).

Therefore, the main goal of this study is to find out how the quality of dried banana rings is affected by pretreatments (Sodium metabisulphate - SO_2) and the air drying method. Determining the mineral content (Fe, Zn, and Cu), color characteristics, rehydration properties, and bioactive compounds (vitamin C, total phenol, total chlorophylls, total carotenoids, and antioxidant activity) in untreated and treated sodium metabisulfite (SO_2) air-dried banana rings was the second goal.

2. Material and Methods:

2.1. Materials:

High purity solvents and chemicals were acquired from El-Gomhoria Company for Chemicals and Drugs, Cairo, Egypt. The Grand Nain type bananas were acquired at the local fruit and vegetable store in Cairo, Egypt, in September 2023. Banana fruits were picked for their consistent color and size, absence of pests, and physical damage. The samples were taken to the Laboratory of Food Technology, Food

Technology Department, Food Industries and Nutrition Research Institute, National Research Centre, Giza, Egypt, for processing before drying by air fryer. **2.2. Preparation of Pretreatment of Bananas rings and air Drying by fryer apparatus**: A knife is also a completely appropriate approach to cut bananas into rings for the drying process. You may cut the banana rings into a steady size thin layer. The banana rings were prepped before air dryer drying using pretreatment sodium metabisulphite (Na2S2O5) 0.05% and one sample was untreated and served as the control. To make the sodium metabisulphite 0.05% therapy, 10 g of sodium metabisulphite was dissolved in 2000 mL of distilled water. About 1000 g of banana rings were weighed for pretreatment for 10 min; following pretreatment, they were exposed to drying using air drying fryer equipment. Whereas, arrange untreated and SO2-treated bananas rings on a wire rack on a drying sheet. This permits the air drying in fryer tool to circulate around the banana rings for 20-25minutes. Figures (1 and 2) demonstrated that the image of control or untreated dried banana rings by air drying fryer and SO2-treated dried banana rings by air drying fryer equipment.

2.3. Estimation of Thermo-Physical Parameters:

2.3.1. Initial Moisture Content: The oven was set at 105 ∘C to measure the initial moisture content until a consistent weight was attained (A.O.A.C. 2016), and the equation that follows was employed:

Mid = (Wm / Wd) × 100 ---(1)

where Mid is moisture content on a dry basis (%), Wm is moisture content in the sample (g), and Wd is dry material content (g).

2.3.2. Moisture (Mt)

Every 30 min, the moisture percentage and wet basis (w.b.) percentage were calculated as follows **(A.O.A.C. 2016)**.

Mt = Wt – Wo (1 – mo) / Wt ---(2)

where Wt is sample weight (g) at any time, Wo is fresh sample weight (g), and mo is initial moisture percent (w.b.%).

2.3.3. Moisture Dehydration:

Dry basis moisture content is the quantity of water per unit mass of dry solids. It is represented as the mass of water to the mass of dry solid[1]. Dry basis moisture content may vary from 0 to extremely significant percentages. It is commonly used in drying and humidification calculations. Wet basis moisture content is computed using the formula:

M = 100 x (Wet Weight – Dry Weight) / Wet Weight--(3)

2.3.4. Rehydration Ratio:

The rehydration ratio (RR) experiments were done after immersing five grams of dried banana slices in 300 mL of distilled water at ambient temperature; subsequently, the slices were drained and weighed. Based on the following equation, the quantity of water rehydration was quantified as RR (Dehghannya et al., 2019 and Gomaa et al., 2023)..

RR = M after soaking / M before soaking --(4)

where M is the sample weight (g).

2.3.5. Moisture Content Formula (moisture coefficient)

The following formula can be used to calculate moisture content (Gomaa et al., 2023).

MC = (w – d) / w X100---(5)

Where:

Where MC is the moisture content (%), w is the weight while wet and d is the weight while dry

2.3.6. Shrinkage Ratio (SR):

The shrinkage ratio can be defined as the ratio of given volume change to the corresponding change in water content of the soil sample. The given volume change is expressed in terms of percentage of the dry volume (Gomaa et al., 2023).

The shrinkage ratio can be given by the formula:

Shrinkage Ratio (SR) = (V1 - V2) / Vd * 100 / (w1 - w2)--(6)

Where, V1 is the volume of the soil mass at a water content ‘w1’, ‘V2’ is the volume of the soil mass at a water content of ‘w2’. ‘Vd’ is the volume of the dry soil mass.

If w2 is the water content corresponding to the shrinkage limit, then V2 becomes Vd, then shrinkage ratio is given by:

2.3.7. Drying Rate or dehydration ratio (Drying Ratio):

The drying rate was calculated as follows (Gomaa et al., 2023):

DR = Drying rate = Mt – dt – Mt / dt = Kg (water) / hour --(7)

where Mt – dt and Mt are the moisture contents at dt and t times, respectively, and dt is the drying period (hour).

2.4. Analytical Methods of Quality Parameters:

2.4.1. Colour determination:

Colour of Egyptian banana fresh, untreated air dried and SO_2-treated air dried banana rings was assessed using spectro-colourimeter (Tristimulus Colour Machine) using the CIE lab colour scale (International Commission on Illumination) as indicated by Hunter (1975) and Sapers and Douglas, (1987). Colour of Fresh, untreated air dried and SO_2-pretreated air driedbanana rings samples was evaluated using a HunterLab colourimeter Hunter a*, b* and L*. Parameters were measured using a color difference meter utilizing a spectro-colourimeter (Tristimulus color Machine) with the CIE lab colour scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode. The instrument was standardized each time with white tile of Hunter Lab Colour Standard (LX No.16379): X = 72.26, Y = 81.94 and Z = 88.14 (L*= 92.46; a*= -0.86; b*= -0.16).

The apparatus (65°/0° geometry, D25 optical sensor, 10° observer) was calibrated using white and black reference tiles. The color values were denoted as L* (lightness or brightness/ darkness), a* (redness/greenness) and b* (yellowness/blueness). Whereas, the L* denotes brightness/darkness index (0–100/black to white), a* shows redness/greenness ('+' values for red, '−' values for green), and b* indicates yellowness/blueness ('+' values for yellow, '−' values for blue). The Hue (H)*, Chroma (C)* and Browning Index (BI) was computed according to the approach of Palou et al. (1999) as follows:

$H^* = \tan^{-1} [b^*/a^*]$……………………………………………………………........(8)

$C^* =$ square root of $[a^{2*} + b^{2*}]$……………….……………………………………………(9)

$BI = [100 (x-0.31)]\ 10.72$…………………….……………………………………………(10)

Where:- $X = (a^* + 1.75L^*) / (5.645L^* + a^* - 3.012b^*)$

3.4.2. Mineral Determination:

Iron, zinc and copper concentrations of fresh, untreated dried banana rings and SO_2-treated dried banana rings samples were tested in the digested solution according to the technique proposed by Jackson (1973). Mineral content (Fe, cu and Zn) of fresh and SO_2-treated dried zucchini rings was analyzed using a Unicom SP 1900 atomic absorption spectrophotometer (FMD3) according to the technique of (A.O.A.C. 2000 procedure, No 980.03).

3.4.3. Total carotenoids and chlorophylls Determinations:

The technique published by Wettestein (1957) was utilized for the estimation of total carotenoids and chlorophylls represented as mg/L.

3.4.4. Vitamin C (L-ascorbic acid) (AA):

L-Ascorbic acid was measured by the 2.6-dichlorophenol indophenol titrimetric technique as defined in A.O.A.C. methodology no. 967.21 (A.O.A.C., 2000). Comparative assessments of vitamin C content in fresh, untreated dried banana rings and SO_2-treated dried banana rings samples was carried out using the same approach, where 0.1 g of each sample was weighed and diluted in 1 L distilled water. The vitamin C concentration was represented as g AA retained / g AA initial.

2.4.4.1 Extraction and Determination of Total Phenol and DPPH

Five grams of fresh, untreated dried banana rings and SO2-treated dried banana rings samples were suspended in 40 mL of 80% ethanol for 12 hours at room temperature. The mixture was centrifuged at 10,000×g for 20 minutes, and the supernatant was collected and filtered through Whatman No. 1 filter paper to acquire the crude extract, as described by Soong and Barlow (2004).

2.4.4.2. Total Phenolic Content (TPC) Determination:

For TPC analysis in fresh, untreated dried banana rings and SO2-treated dried banana rings samples, 600 μL of the crude extract was mixed with 600 μL of Folin–Ciocalteu reagent, following the methodology suggested by Yu et al. (2002). To this mixture, 4.8 mL of clean water was added. The solution was incubated in the dark at room temperature for 90 minutes to allow the reaction to proceed. Absorbance was evaluated at 765 nm using a UV–visible spectrophotometer (Thermo Electron Company, Beverly, MA, USA). The TPC was determined using a gallic acid standard curve and reported in milligrams of gallic acid equivalents (mg GA/kg dry weight).

2.4.5. DPPH Radical Scavenging Activity Assay: To examine the antioxidant activity using the DPPH radical scavenging test in fresh, untreated dried banana rings and SO2-treated dried banana rings samples, 100 μL of the crude extract was added to 100 μL of a 0.2 mM DPPH solution prepared in methanol. The mixture was kept at room temperature in the dark for 60 minutes, as per the protocol of Brand-Williams et al. (1995). Absorbance was measured at 517 nm using the same UV–visible spectrophotometer. The DPPH radical scavenging activity was expressed as a percentage of inhibition using the following equation:

$$\%\text{Inhibition} = \left(\frac{A_0 - A_1}{A_0}\right) \times 100$$
--(11)

Where $A_0$is the absorbance of the control (DPPH solution without extract) and A_1 is the absorbance of the sample (DPPH solution with extract).

2.5. Statistical Analysis:

The mean values and standard error were used to represent the findings. Every analytical test was done in triplicate. The mean values were submitted to examination using a two-way analysis of variance (ANOVA) to check for significant differences ($p < 0.05$) using SPSS (version 22).

3. Results and Discussions:

3.1. The properties of rehydration of pretreatment and SO_2 -treated air-dried banana rings and their relationship to pretreatment-dried banana rings:

According to Table (1), the drying ratios for the pretreatment and SO_2-treated air-dried banana rings were 1:4 and 1:5, respectively, and the rehydration ratios were 1:44 and 1:40 for the pretreatment and SO_2-treated air-dried banana rings. Pretreated air-dried dehydrated banana rings had a moisture percentage of 67.44 percent, while SO_2-treated air-dried banana rings had a moisture content of 72.69%. Additionally, the pretreatment air-dried and SO_2-treated air-dried banana rings had rehydration coefficients of 3.37 and 2.71 percent, respectively. According to Table (1), the shrinkage ratios of the pretreatment air-dried and SO_2-treated air-dried banana rings were 1:10 and 1:10, respectively. Then, pretreatment with SO_2 did not effect on rehydration characteristics of untreated and SO_2-treated air-dried banana rings' and how they relate to of pretreatment-air dried banana rings. The SO_2-treatments demonstrated that an amorphous state may emerge in the late stages of convection drying of bananas, and that severe shrinkage can be avoided by increasing the material's mechanical strength. When water was added during re-hydration, the glassy matrix and a structural collapse were seen. Swelling and structural reconstruction were seen as a result of the polymers' continued water absorption. These findings were consistent with those of **(Eissa et al., 2013;** Lewicki et al., 1997; Karathanos et al., 1996). In comparison to the pretreatment air-dried banana rings sample, the SO_2-treated air-dried banana rings sample had a significantly lower re-hydration ratio (index). These findings concurred with those of Lewicki (1998**)**, who found that the greater the loss of water absorption capacity.

Table (1): Effect of SO_2 pretreatment and air drying process on rehyration properties and thermo-physical parameters of banana rings.

Rehydration properties	**Banana rings air dried**	**Banana rings SO_2-air dried**
Rehydration ratio	1:44	1:40
Moisture coefficient	3.37	2.71
Moisture dehydration	67.44	72.70
Dehydration ratio (Drying ratio)	1:40	1:50
Shrinkage ratio	1:10	1:10

3.2. Effect of untreated dried and SO_2 - treated air drying process on mineral contents of dried banana rings:

Mineral content of dried banana rings as a result of untreated and SO_2-treated air drying processes:

Table (2) provided the mineral content (per 100 g) of the air-dried and untreated dried banana rings as well as the SO_2-pretreatment. While the mineral content of untreated air-dried banana rings was 26.56, 8.73, and 4.36 ppm, and that of SO_2-treated air-dried banana rings was 62.60, 18.15, and 6.49 ppm, respectively, fresh banana rings had iron, zinc, and copper contents of 14.14, 3.26, and 0.81 ppm. According to Table (2), the fresh banana rings had the lowest mineral contents (0.81–14.14 ppm), whereas the SO_2-treated and untreated air-dried banana rings samples had the highest amounts (6.49–62.60 ppm) and 4.36–26.56 ppm).

However, the results showed that the SO_2-treated air-dried banana rings sample had higher levels of all mineral elements (Fe, Zn, and Cu) than the fresh and untreated air-dried banana rings sample. Important minerals like Fe, Zn, and Cu have been found in fresh bananas; however, the amount of these minerals in the SO_2-treated air-dried banana rings sample was higher than in the fresh sample. **Eissa et al. (2013)**, Mandhare et al. (2003), **and** Asaduzzaman et al. (2009) all verified the same findings. The iron results are consistent with those published by Soylak et al. (2005). Additionally, **Joshi and Mehta (2010)** discovered that the dehydrated samples of green leafy vegetables had much higher iron content.

Table (2): Effect of air drying process and SO_2pretreatment on mineral concentrations (ppm) of banana rings.

Parameters	**Fresh banana rings**	**Air dried banana rings**	**Treated (SO_2) air dried banana rings**
Iron (Fe)	14.14	26.56	62.60
Zinc (Zn)	3.26	8.73	18.15
Copper (Cu)	0.81	4.36	6.49

3.3. Colour characteristics and parameters in untreated and SO_2 – treated air dried banana rings:

Using the Hunter Lab color scale, a color difference meter was used to measure the surface color of untreated and SO_2-treated air-dried banana rings. As soon as the banana rings sample was allowed to air dry, the Hunter color values were ascertained. The Hunter colors' a*value changes were inversely correlated with changes in L* values. Due to non-enzymatic browning during processing, the CIE L*, a*, b* color parameters, hue angle (H*), chroma (C*), and BI were shown to be appropriate markers for the generation of brown pigment, as shown in Table (3).

In contrast to the high values for the untreated air-dried banana ring sample, the a* values and BI for the SO_2-treated air-dried banana ring sample were low. While the untreated sample exhibited the opposite trend, the SO_2 treated air dried shown significantly greater efficient values based on L*, b*, and C* values compared to a*, H*, and BI-value measurements under all evaluated conditions. This pattern is consistent with earlier research by **Ozoglu and Bayindirh (2002)**. Furthermore, SO_2 treated in air-dried banana rings had lower Hunter color a* and H* values and BI than untreated samples. These findings showed that untreated samples had more browning (redness) than samples of air-dried banana rings treated with SO_2. PPO enzyme activity, however, was greater.

Our findings showed that increases in the BI and a* values, which were highly correlated with the browning measurement, were the primary source of the color changes in the untreated banana rings. Other color metrics, like hue angle H* and chroma C*, also showed that banana rings that were air dried with SO_2 saw minor color alterations. Compared to untreated dried samples, BI values were lower in SO_2-treated dried samples. These findings concur with those of **Ozoglu and Bayindirh (2002), Eissa et al. (2013), and** Palou et al. (1999). The color of air-dried banana rings was commonly observed to be improved by SO_2 treatment (Table 3).

The reaction between amino groups and active carbonyl groups (Maillard reaction) following the air drying process may be the cause of the color increase (browning as a*- and BI values). It has been demonstrated that sulfur dioxide, when combined with carbonyl groups, effectively prevents browning. According to Table (3), the results above suggest that, when compared to the untreated dried banana rings sample, the pretreatment banana rings with SO_2 displayed the best and lower color values (a* and BI) as non-enzymatic browning.

SO_2 was the best pre-treatment for air-dried banana rings because it inhibited oxidative enzymes (PPO), produced good color features, and reduced non-enzymatic browning as measured by a*- and BI values. Table (3) displays a correlation between the various metrics that were examined. When banana rings were air dried, their a*, H*, and BI values decreased while their L*, C*, and b-values increased (Table 3). Table (3) displays the findings for the independent variables' linear and quadratic impacts on the color parameters (L*, a*, b*, Chroma, BI, and Hue angle).

Table (3): Effect of air drying process and SO_2pretreatment on colour characteristics and parameter of banana rings.

Colour parameters	Untreated Air dried banana rings	Treated (SO_2) air dried banana rings
L*-value	56.03	92.46
a*-value	7.00	4.36
b*-value	25.6	28.91
C*-value	26.54	29.24
H*-value	74.71	63.93
BI-value	125.14	73.24

3.4. Effect of SO_2 - pretreatment and air drying processes on micronutrients as a bioactive compounds content of air-dried banana rings:

The fresh and untreated banana ring sample had a minimum level of 0.20 mg/100g of total carotenoids, a maximum of 0.34 mg/100g in untreated air dried, and a maximum of 0.22mg/100g in SO_2-treated air dried. Despite taking less time than untreated drying, SO_2-treated air drying resulted in a reduced loss of total carotenoids. Total chlorophyll (A and B) rose from 5.05mg/100g in the fresh sample to 4.28 and 5.58 mg/100g in the untreated and SO_2 treated air-dried banana ring samples, respectively, according to the data in Table (4).

When compared to untreated dried or fresh samples, the pre-treatment with SO_2 resulted in a lower level of total carotenoids and total chlorophyll (A and B) in air-dried banana rings. By stopping the degradation of total chlorophyll (A and B) and total carotenoids in air-dried banana rings, SO_2 may also be the cause of browning inhibition (PPO).

These findings are consistent with those of Mazza and Miniati (1993**)**, who found that the stability and color intensity of total carotenoids and chlorophyll (A and B) are influenced by the ascorbic acid level and sugar degradation in fruit. Nonetheless, the oxidation of total carotenoids and chlorophyll (A and B) was inhibited by the SO_2 pre-drying treatments.

Additionally, they discovered that PPO could directly breakdowns total carotenoids and total chlorophyll (A and B). When the nutrients of fresh and air-dried vegetables are compared, the air-drying process appears to be superior overall, particularly when it comes to the retention of total carotenoids after air drying. This implies that the drying circumstances, as noted in previous research, are one of the factors influencing the reduction in total carotenoids. The duration of exposure to light, oxygen, heat, and other accelerating elements may be the source of the variations in losses brought on by the air drying processes. Because it might help explain why air-dried samples lost more total carotenoids than fresh ones **(**Kiremire et al., 2010).

According to Table (4), the total phenol content of the fresh sample was 112.06 mg/100g, but after the SO_2 pretreatment and air drying procedure, it rose to 133.14 and 188.26 mg/100g for the untreated and SO_2-treated air dried banana rings samples, respectively. In comparison to fresh samples, samples of air-dried banana rings treated with SO_2 were found to have higher levels of vitamin C, total chlorophyll, total carotenoids, and total phenol. Because vitamin C acid is a potent reducing agent and can be deactivated by a variety of oxidizing agents, it is chemically unstable. The amount of ascorbic acid in the banana rings was significantly lower in the untreated and SO_2-treated air-dried banana rings samples 2.31 and 2.46 mg/100g than in the fresh sample, which had 5.003 mg/100g.

By halting the breakdown of vitamin C in air-dried banana rings, the addition of SO_2 and the removal of water through rehydration may be the cause of the increase in ascorbic acid content in the SO_2-treated air-dried banana rings sample **(**Inyang and Ike, 1998**)**. Since the SO_2-treated air-dried banana ring sample had the highest concentration of vitamin C, this method spares the sample from exposure to air and heat.

Ascorbic acid retention was impacted by the SO_2-pretreatments applied to the banana rings prior to drying (Table 4). Ascorbic acid loss in the untreated dried sample was found to be as high as 49% in SO_2-treated air-dried banana samples and as low as 46% in the untreated dried sample.

One possible explanation for the higher ascorbic acid retention in SO_2-treated air-dried banana rings is that the sample was exposed to less drying air, preventing its loss **(**Verma and Gupta, 2004**)**. Nonetheless, the sample's ascorbic acid loss was lessened by the sulphitation (SO_2) treatments. Leaching is yet another significant element that might have contributed to the drying process's loss of water, soluble minerals, and vitamin C.

As can be observed in table (4), the antioxidant activity (as a percentage of inhibition) was 6.09% in the fresh sample and 12.32 and 14.24% in the untreated and SO_2-treated air-dried banana rings respective. However, as shown in Table (4), the antioxidant activity (as %inhibition) content increased from 6.09% in the fresh sample to 12.32 and 14.24% in the untreated and SO_2-treated air dried banana rings samples, respectively, as a result of the SO_2 pretreatment of the air drying process. Vitamin C, total chlorophyll, total carotenoids, total phenol levels, and antioxidant activity (as a percentage of inhibition) were all higher in SO_2-treated air-dried banana ring samples than in fresh samples.

Table (4): Effect of air drying process and SO_2 pretreatment on bioactive compounds content of banana rings.

Parameters	**Fresh banana rings**	**(SO_2) treated air dried banana rings**	**Air dried banana rings**
Vitamin C (mg/100g)	5.003	2.46	2.31
Total phenol (mg/100g)	112.06	188.26	133.14
Chlorophyll A (mg/100g)	2.13	1.85	1.42
Chlorophyll B (mg/100g)	2.91	3.74	2.86
Total Chlorophyll (mg/100g)	5.05	5.58	4.28
Total Carotenoids (mg/100g)	0.20	0.34	0.22
Antioxidant activity (% inhibition)	6.09	14.24	12.32

4. Conclusion

The characteristics of dried banana rings are evaluated in relation to pretreatment solutions (sodium metabisulphate-SO_2) and drying methods (air drying (AD)). The current study concludes that the quality of air-dried banana rings is significantly influenced by the use of pretreatment techniques using sodium metabisulfite (SO_2). The impact of sodium metabisulfite (SO_2) pre-treatment techniques on mineral content (Fe, Zn, and Cu), color features, rehydration qualities, and bioactive components (vitamin C, total phenol, total chlorophylls, total carotenoids, and antioxidant activity) has been demonstrated. For the majority of the quality assessment criteria, the banana rings that had been prepared with sodium metabisulphite-SO_2 showed good characteristics. Therefore, based on these findings, the finished banana ring product may have a lot of commercial potential as a raw product or as a component for infant foods. Pretreatment methods already play a big part in preserving the final quality of dried banana rings and have a lot of potential applications in the food sector. Moreover, AD is an alternative drying technique that yields reasonably high-quality products with enormous commercial potential.

Declarations

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Declaration of Interest Statement

No declaration off interest statement

Ethics approval and consent to participate

“Not applicable” in this section.

Availability of data and materials

All data generated or analyzed during this study already exist in this published article.

Consent for publication

“Not applicable” in this section.

Competing interests

Authors declare that they have no competing interests.

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Figures

Figure 1

Untreated air drying dried banana rings

Figure 2

SO_2-treated air drying dried banana rings