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The Use of Sorrel (*Rumex Acetosella*) Extract and Dia Natura Base As Natural Pre-Treatments and Its Expected Effects for Color Preservation in Dried Citrus Fruits

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Abstract. Drying is one of the oldest and most common methods for food preservation, aiming to reduce water content to inhibit microbial and enzymatic activity. However, the thermal process, particularly hot-air drying, often leads to significant degradation of product quality, including undesirable color changes and the loss of vital nutritional components. Previous studies on citrus drying have consistently reported significant losses in ascorbic acid (Vitamin C), total phenolic content, and antioxidant capacity, with the drying technique and temperature being critical factors (Karabacak et al., 2020; Bozkır, 2020; İsmail et al., 2024).

To mitigate this degradation, pre-treatments are widely applied. Conventional methods often involve inorganic solutions such as sulfuring or alkaline baths, which have raised significant health concerns. Consequently, there is a growing demand for safe, effective, and natural pre-treatment alternatives that do not impart off-flavors or odors. While antioxidant solutions like ascorbic and citric acid are used (Soydan, 2019), the exploration of novel, plant-based extracts is a key research gap. This study aims to investigate the efficacy of sorrel (*Rumex acetosella*) extract and a commercial natural preservative, Dia Natura Base, as novel pre-treatments for preserving quality in dried citrus slices (orange, tangerine, and grapefruit). Sorrel is known to be rich in antioxidants and vitamins A, B, and C (ascorbic acid) (Baytop, 1984; Zeybek & Zeybek, 2002), and its extracts have demonstrated antimicrobial and antiviral properties (Ilçım et al., 1998; Bütüner, 2022). To date, while the drying kinetics of sorrel leaves have been studied (Açıkalın, 2021), its extract has not been utilized as a pre-treatment agent in fruit drying, representing a significant novelty.

In this research, citrus slices of varying thicknesses (3, 5, and 7 mm) will be subjected to hot-air drying at five different temperatures (50, 55, 60, 65, and 70 °C). The pre-treatments will involve dipping the slices in sorrel extract and Dia Natura Base solutions at different concentrations (5%, 10%, 25%) and durations (5, 7, 10 min). Quality parameters will be assessed by measuring color change ($L^{*}a^{*}b^{*}$), ascorbic acid content via HPLC (Sdiri et al., 2012), HMF content (Tontul & Topuz, 2017), and functional group changes via FTIR. Furthermore, the stability of these quality parameters will be evaluated during a 4- and 6-month shelf-life study. This project is expected to validate a natural, organic pre-treatment method that can enhance the quality and safety of dried citrus products.

Keywords: Citrus, Drying, Sorrel, *Rumex acetosella*, Pre-treatment, Color Preservation, Dia Natura Base

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1 Introduction

Drying stands as one of the most ancient methods for ensuring the preservation and extending the shelf-life of food products. The primary objective of the drying process is to reduce the moisture content of the food by evaporating its water. This reduction in water activity effectively inhibits or completely halts the microbial and enzymatic activities that lead to spoilage (Simal et al., 1997).

However, the efficacy of this preservation method is heavily dependent on its impact on the final product's quality. It is expected that dried fruits and vegetables retain critical quality attributes such as flavor, appearance, color, and nutritional value as closely as possible to their fresh state. Furthermore, they must possess high rehydration capacity (Doymaz & Aktaş, 2017).

To meet these quality expectations and enhance drying efficiency, a series of pre-treatments are applied to foods before the drying process. Beyond fundamental procedures like sorting, classification, and washing, more specific interventions are employed, particularly to ensure color and textural stability. These interventions, such as sulfuring, alkaline solution application, blanching, and salting, are of greater significance in the preservation process (Şen, 2013).

The inorganic nature of many conventional pre-treatment solutions, especially sulfites, has given rise to significant health concerns among consumers. This has driven a clear demand for natural, organic extracts that can effectively prevent quality degradation without imparting any undesirable taste or odor (Yıldız, 2021). The browning in citrus, for instance, is not solely due to the loss of ascorbic acid; it is also a result of enzymatic activity from polyphenol oxidase (PPO). Therefore, an effective pre-treatment must address both enzymatic browning and chemical oxidation.

While some studies on citrus drying have focused on optimizing drying parameters or comparing drying technologies (e.g., Karabacak et al., 2020; Bozkır, 2020; İsmail et al., 2024), and others have examined the drying of sorrel leaves themselves (Açıkalın, 2021), a significant gap in the literature exists: no previous study has investigated the use of Rumex acetosella (Sorrel) extract as a natural, anti-browning pre-treatment for the drying of citrus fruits.

This study aims to fill this gap by evaluating the efficacy of sorrel extract, a plant known to be rich in natural antioxidants including ascorbic acid (Baytop, 1984), as a novel pre-treatment agent. Its performance will be compared against a control group and a commercial natural preservative (Dia Natura Base) to determine its potential for preserving color and nutritional quality in dried orange, tangerine, and grapefruit slices.

2 Materials and Methods

2.1 Plant Materials and Reagents

Three citrus varieties, tangerine (Citrus reticulata), orange (Citrus sinensis), and grapefruit (Citrus Parasidi), will be used as the primary materials. These fruits will be sourced from a local market. The sorrel (Rumex acetosella) plant, used for the pre-treatment extract, and the commercial natural preservative Dia Natura Base will constitute the other main materials. Dia Natura Base will be procured directly from the supplier. Analytical grade chemicals, including water, ethanol, and methanol for extraction, and metaphosphoric acid and orthophosphoric acid for HPLC analysis, will be used.

2.2. Preparation of Sorrel Extract

The sorrel plant will be dried in a laboratory setting at ambient temperature and in the shade. Ten grams (10 g) of the dried plant material will be ground into a powder using a blender. The powdered sample will be placed in a 1-liter Erlenmeyer flask and mixed with a 20-fold volume (200 mL) of solvent (water, ethanol, and methanol). The mixture will be agitated on a magnetic stirrer until the extraction solvent becomes colorless, with the solvent being replaced periodically. The resulting mixture will be filtered through filter paper, and the solvent will be evaporated to yield the final extract.

2.3. Experimental Design and Drying Process

The study will be conducted with 3 replications. The citrus fruits will be sliced into rounds of three different thicknesses: 3, 5, and 7 mm. The slices will be divided into a Control group and two pre-treatment groups: Sorrel Extract and Dia Natura Base. The pre-treatment applications will be carried out at three different solution concentrations (5%, 10%, and 25%) and for three different immersion durations (5, 7, and 10 minutes).

All slices (pre-treated and control) will be dried in a hot-air oven, representing commercial conditions, at five different temperature levels: 50, 55, 60, 65, and 70 °C.

2.4. Moisture Content and Drying Kinetics

The initial moisture content of the fresh samples will be determined by drying 50 g samples in an oven at 105 °C for 24 hours (wet basis). These values will also be verified using an Ohaus MB45 moisture analyzer. During the drying process, the mass change of the samples will be continuously recorded using an automated weighing system and a Sartorius GM 1502 precision balance (±0.01 g). From this data, the moisture content on a dry basis (X_{KB}), Drying Rate (DR), and Moisture Ratio (MR) will be calculated.

2.5. Color Analysis

The color parameters of the dried products will be measured using a dark box system and an Olympus E620 digital camera. Environmental light effects will be eliminated using a matte black box (300x300x300 mm) and LED lamps providing 1440 lx illumination. The captured images will be analyzed using Adobe Photoshop and ImageJ software according to the CIE $L^{*}a^{*}b^{*}$ color scale. Total color change (ΔE), Browning Index (BI), Chroma (C), and Hue angle (α) will be calculated using their respective formulas.

2.6. Quality and Shelf-Life Analysis

Dried citrus slices will be packaged in 100 g low-density polyethylene (LDPE) bags and stored at ambient temperature (22-24 °C) for 4 and 6 months. During storage, monthly analyses will be conducted for moisture content, water activity (aw), color values, HMF, and Ascorbic acid content.

2.6.1. Ascorbic Acid (Vitamin C) Analysis

Ascorbic acid content will be determined by High-Performance Liquid Chromatography (HPLC) according to the method proposed by Sdiri et al. (2012). Samples will be extracted with 3% metaphosphoric acid (HPO3) and analyzed using an Inertsil ODS-3 C-18 column at 243 nm with a flow rate of 0.5 mL/min.

2.6.2. HMF (5-Hydroxymethylfurfural) Analysis

HMF content will be determined by HPLC as per the method of Tontul and Topuz (2017). An Inertsil ODS-3 C-18 column will be used with a water:methanol (90:10, v/v) mobile phase, with detection at 285 nm and a flow rate of 1 mL/min.

2.6.3. FTIR Analysis

FTIR spectroscopy will be employed to determine the macro and micro-element composition of the products. This analysis will be conducted as a service procured from the Central Research Laboratory.

2.7. Statistical Analysis

All data will be subjected to Analysis of Variance (ANOVA) using SPSS software. Statistically significant differences between means will be evaluated using the Duncan multiple range test.

3. Expected Results and Discussion

This research is anticipated to provide significant insights into the practical application of natural extracts as substitutes for conventional inorganic pre-treatments in food drying.

1. **Efficacy of *Rumex acetosella* (Sorrel) Extract:** It is hypothesized that the citrus slices pre-treated with the sorrel extract will exhibit significantly better quality retention compared to the untreated control group. The high antioxidant and ascorbic acid content inherent to sorrel (Baytop, 1984) is expected to provide a protective effect, inhibiting the polyphenol oxidase (PPO) enzymes responsible for enzymatic browning.
2. **Color Preservation:** The primary success criterion will be color stability. It is expected that the sorrel-treated and Dia Natura Base-treated samples will show significantly higher L^{*} (lightness) values and lower a^{*} (redness) values compared to the control. Consequently, the total color change (ΔE) and Browning Index (BI) values are expected to be lowest in the extract-treated groups, indicating successful prevention of browning.
3. **Nutritional Retention:** The control group is expected to follow the trend seen in previous literature (Karabacak et al., 2020; Bozkır, 2020), showing a significant loss of ascorbic acid. It is hypothesized that the sorrel extract, by acting as a sacrificial antioxidant, will protect the endogenous ascorbic acid in the citrus slices, leading to a much higher retention of Vitamin C in the final dried product.

4. **Shelf-Life Stability:** The protective effects are expected to extend into the shelf-life study. The control samples may continue to degrade in storage, whereas the pre-treated samples are expected to maintain their color and nutritional quality for the 4- and 6-month period, as evidenced by stable ascorbic acid and low HMF levels.
5. **Optimization of Parameters:** The study will also identify the optimal pre-treatment conditions (concentration and immersion time) and drying temperatures that yield the highest quality product, providing a practical, scalable protocol for industrial application.

In conclusion, this study provides a novel, organic, and cost-effective solution to a persistent problem in the food industry. By validating sorrel extract as a viable pre-treatment, this research will contribute to the production of safer, healthier, and more appealing dried fruit products, meeting the growing consumer demand for "clean label" foods.

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