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Impact of Tray Dryer and Fluidized Bed Dryer on the Bioactive Compounds of *Dalbergia sissoo* Leaves

Gediya V. K.[1], Bhalodiya V. B.[2], Akbari S. H.[3]

[1]M.Tech Scholar, Department of Food Process Engineering, College of Food Processing Technology and Bio Energy, AAU, Anand
[2]Associate Professor and Head, Department of Food Process Engineering, College of Food Processing Technology and Bio Energy, AAU, Anand
[3]Associate Professor and Head, Department of Food Plant Operations, College of Food Processing Technology and Bio Energy, AAU, Anand

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Abstract - *The use of natural resources, especially plants, for medicinal purposes has a rich history spanning thousands of years. Dalbergia sissoo, commonly known as Shisham, is a deciduous tree of significant botanical and cultural importance in the Indian subcontinent. The leaves of Dalbergia sissoo are traditionally used for treating various health conditions due to their rich bioactive compound content, including phenolics and flavonoids. However, high perishability of fresh leaves necessitates effective drying methods to preserve their medicinal properties. The presented study investigates the impacts of tray drying and fluidized bed drying on the bioactive compounds in Dalbergia sissoo leaves. Fluidized bed drying was found more effective in preserving phenolic and flavonoid contents as well as antioxidant activity, compared to tray drying. These findings highlight the importance of optimizing drying techniques to maintain the therapeutic properties of medicinal plants.*

***Key words*: *Dalbergia sissoo*, Drying, Total Phenol, Flavonoid, Tray Dryer, Fluidized bed dryer**

1. INTRODUCTION

The use of natural resources, especially plants, for medicinal purposes has a rich history spanning thousands of years. Ancient scriptures like the Rigveda, Charak Samhita, and Sushruta Samhita provide evidence of medicinal plants being employed to address various health issues. In contemporary times, particularly in areas with limited access to modern medical care, herbal medicines continue to play a crucial role in treating diverse illnesses and are an essential part of cultural traditions globally, including in India [1].

Dalbergia sissoo, commonly referred to as Shisham, is a deciduous tree in the Fabaceae family. It is indigenous to the Indian subcontinent and southern Iran. This tree holds considerable botanical and cultural significance, flourishing along riverbanks and at altitudes up to 1,300 meters. The leaves of *Dalbergia sissoo* are notable for their leathery texture and pinnately compound structure, making them valuable for various medicinal uses. Traditionally, different parts of the tree, such as its bark, seed oil, and leaves, have been utilized to treat a variety of health conditions, including skin ailments, heart issues, digestive disorders, and syphilis [2].

Phenolic compounds are vital for protecting plants from UV radiation, diseases, parasites, and predators, as well as enhancing their coloration. These compounds are present throughout all plant organs, making them a significant part of human nutrition. They are found in a variety of plant-based foods, including fruits, vegetables, cereals, and beverages like tea and coffee, where they greatly affect sensory properties. Among polyphenols, flavonoids are the most common in human diets. They possess anti-inflammatory and antiviral properties and are noted for their protective effects against cardiovascular diseases and cancer, earning them comparisons to essential vitamins [3].

A major challenge in using *Dalbergia sissoo* leaves for medicinal purposes is their high perishability. Fresh leaves are susceptible to spoilage due to moisture, microbial growth, and inadequate storage conditions. To maintain their availability throughout the year and preserve their nutritional and bioactive properties, effective drying methods are crucial. Drying extends the shelf life of the leaves and also reduces their weight and volume, making transportation easier [4].

Conventional drying techniques, including shade drying and open sun drying, are commonly employed; However, they associated with significant drawbacks. These techniques frequently lead to the loss of volatile compounds and bioactive components due to exposure to strong solar radiation and potential contamination from environmental factors. On the contrary, modern drying techniques, such as forced convection drying, offers more regulated and efficient alternatives. Specifically, tray dryers and fluidized bed dryers improve heat and mass transfer, resulting in better preservation of bioactive compounds and minimizing contamination risks [5].

Given that drying can constitute 30-50% of the total production expenses in medicinal plant processing, optimizing drying techniques is essential. Effective drying techniques not only help preserve the quality of active ingredients but also reduce energy consumption. This study aims to investigate the impact of two drying methods-tray drying and fluidized bed drying-on the bioactive compounds in *Dalbergia sissoo* leaves. By comparing these methods, determine the most efficient and cost-effective approach for maintaining the therapeutic properties of the leaves [6].

2. MATERIALS AND METHOD

2.1 Tray Dryer

The drying experiments utilized a Narang Scientific Works Pvt. Ltd. Tray dryer from Delhi, equipped with a manually controlled digital thermostat, a 0.5 hp motor-driven blower, 3 kW electric finned heaters, and a PT-100 thermocouple for temperature measurement. Temperatures of 45, 50, 55, and 60 °C were selected with an air velocity of 1 m/s. Samples were weighed using a digital balance (ASCO, AST, India; capacity: 5 kg; least count: 0.01 g), loaded onto trays and dried until achieving 6-8% moisture content on a dry basis. Dried samples were then packed into HDPE bags for subsequent analysis.

2.2 Fluidized Bed Dryer

Powerpac Engineers in New Delhi developed a Fluidized Bed Dryer, featuring a 0.37 kW electric heater and a PID controller. The dryer was preheated for 30 minutes to stabilize temperature and air velocity. *Dalbergia sissoo* leaves, were dried at 45, 50, 55, and 60 °C with 2.4 m/s air velocity. The weight of the samples was recorded every 10 minutes using a precise digital balance. Drying continued until moisture content reached 6-8%. Post-drying, the samples were packed in HDPE bags.

2.3 Total Phenol Content

The total phenolic content of the extract was assessed using the Folin-Ciocalteu method [7]. This method involves the reduction of Folin-Ciocalteu reagent by polyphenols in the sample, resulting in a blue-colored complex. The concentration of phenolics in the extracts was determined using a calibration curve prepared with gallic acid. To create this calibration curve, 0.5 mL aliquots of gallic acid solutions in methanol with concentrations of 12.5, 25, 50, 100, 200, and 400 µg/mL were mixed with 2.5 mL of Folin-Ciocalteu reagent (diluted ten times) and 2.5 mL of sodium carbonate solution (75 g/L). After incubating the mixture at 25 °C for 30 minutes, the absorbance was measured at 765 nm using a UV Spectrophotometer, with a reagent blank as the reference. The calibration curve was plotted using absorbance values against the concentrations. The same procedure was applied to the extract to determine its phenolic content. All measurements were conducted in triplicate, and the total phenolic content was expressed in milligrams of gallic acid equivalent (GAE) per gram of extract.

2.4 Total Flavonoid Content

The total flavonoid content of the methanol extract was assessed using the method described by Jiao with slight modifications [8]. In this procedure, 1 ml of *Dalbergia sissoo* leaves extract or standard solution at varying concentrations was placed in a test tube, followed by the addition of 3 ml of methanol. Next, 200 µl of a 10% aluminium chloride solution and 200 µl of 1M potassium acetate were added to the same test tube. The mixture was then diluted with 5.6 ml of distilled water. After incubating the reaction mixture at room temperature for 30 minutes, the absorbance was measured at 415 nm using a spectrophotometer, with methanol serving as the blank. The total flavonoid content in the *Dalbergia sissoo* leaves extract was expressed in milligrams per gram of quercetin equivalent (QE).

2.5 Antioxidant Activity

The DPPH scavenging activity was assessed using the method described by Braca [9]. Concentration of *Dalbergia sissoo* leaves extract (100 µg/mL) was dissolved in methanol and placed in separate test tube. To test tube, 3 mL of a 0.004% w/v DPPH methanol solution was added. After 30 minutes, the absorbance was measured at 517 nm against a methanol blank. The percentage of inhibition activity was calculated using the formula: [(A0−A1)/A0] × 100, where A0 is the absorbance of the control and A1 is the absorbance of the sample. The control sample was prepared with the same volume but without any extract or reference drug, using methanol as a blank.

3. Results and Discussion

3.1 Effect of Drying Condition on Drying Time

From the table-1, it is evident that there exists an inverse correlation between drying time and drying temperature. Specifically, as the drying temperature increases, the drying time decreases. For instance, in the tray dryer at 45°C, the longest drying time observed was 143.33 minutes. In contrast, in the fluidized bed dryer operating at 60°C, the shortest drying time recorded was only 20 minutes among all treatments. This trend clearly illustrates the impact of temperature on the efficiency of the drying process, where higher temperatures significantly reduce the required drying time.

Table-1 Effect of drying condition on drying time

Dryer	Temperature (°C)	Drying Time (min)
Tray Dryer	45	143.33
	50	110.00
	55	93.33
	60	76.66
Fluidized bed dryer	45	63.33
	50	50.00
	55	43.33
	60	20.00

3.2 Effect of Drying Condition on Total Phenol Content

The phenolic content of dried *Dalbergia sissoo* leaves was assessed using spectrophotometry. Results showed that using a tray dryer, phenolic content ranged from 58.60 mg GAE/g to 62.64 mg GAE/g. In contrast, employing a fluidized bed dryer retained higher phenolic content, ranging from 62.41 mg GAE/g to 67.45 mg GAE/g. This difference suggests that the fluidized bed dryer preserves more phenolic compounds, likely due to its shorter drying duration. Higher temperatures in tray drying may lead to reduced bioactive potential, potentially from polyphenol degradation or structural changes.

Table-2 Effect of drying condition on phenol content

Dryer	Temperature (°C)	Phenol Content (mg GAE/g)
Tray Dryer	45	62.64
	50	61.55
	55	59.36
	60	58.60
Fluidized bed dryer	45	67.45
	50	64.22
	55	63.21
	60	62.41

3.3 Effect of Drying Condition on Flavonoid Content

The table displays the flavonoid content found in dried *Dalbergia sissoo* leaves, showing a range from 20.98 to 22.66 mg QE/g across different drying temperatures. The sample dried using a fluidized bed dryer at 45 °C exhibited the highest flavonoid content. The data suggests that bioactive compounds, particularly flavonoids, experience less degradation when dried at lower temperatures. This difference is attributed to the greater sensitivity of glycosylated flavonoids to heat compared to aglycone flavonoids.

Table-3 Effect of drying condition on flavonoid content

Dryer	Temperature (°C)	Flavonoid Content (mg QE/g)
Tray Dryer	45	22.15
	50	21.63
	55	21.57
	60	21.16
Fluidized bed dryer	45	22.66
	50	21.60
	55	21.59
	60	20.98

3.4 Effect of Drying Condition on Antioxidant Activity

Across various drying methods applied to *Dalbergia sissoo* leaves, the antioxidant activity varied between 42.84% and 48.58%. The highest level of antioxidant activity, 48.58%, was found in leaves dried using a fluidized bed at 45 °C. Conversely, the lowest antioxidant activity, 42.84%, was observed in leaves dried using a hot air tray dryer at 60 °C. Products dried at lower temperatures retained greater amounts of bioactive compounds and exhibited higher antioxidant activity.

Table-4 Effect of drying condition on antioxidant activity

Dryer	Temperature (°C)	Antioxidant Activity (% inhibition)
Tray Dryer	45	48.02
	50	45.78
	55	43.69
	60	42.84
Fluidized bed dryer	45	48.58
	50	45.94
	55	46.28
	60	44.56

4. CONCLUSION

The study revealed that the drying method significantly impacts the preservation of bioactive compounds in *Dalbergia sissoo* leaves. Fluidized bed drying is shown to be superior to tray drying in retaining higher levels of phenolic and flavonoid content as well as antioxidant activity. Specifically, fluidized bed drying at 45°C preserved the highest phenolic content (67.45 mg GAE/g), flavonoid content (22.66 mg QE/g), and antioxidant activity (48.58% inhibition). These findings underscore the critical role of employing effective drying techniques to ensure the availability and therapeutic efficacy of medicinal plants throughout the year. By optimizing drying conditions, it is possible to enhance the quality and longevity of medicinal plant products, making them more suitable for both traditional and modern medicinal applications.

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