Effect of the Tray Drying and Vacuum Oven Drying on Physicochemical, Phytochemical and Volatile profiles of Jaboticaba peel powder

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ABSTRACT: -

*Jaboticaba (**Plinia cauliflora**) peel is an underutilized fruit by-product that is rich in phenolic compounds which can be used as a functional food. This study aimed to investigate moisture content, colour attributes, FTIR characteristics, total phenolic content, and GC-MS profile of the jaboticaba peel powder produced by tray drying and vacuum oven drying processes. The peels were dried using TD (50±2°C for 18 hrs) and VOD (50±2°C for 12 hrs under reduced pressure). The powder produced by VOD showed lower moisture content (6.29%) compared to TD (7.66%) and better colour retention with higher redness (15.19) and lower yellowness (6.86). Hydroxyl, carbonyl, aromatic and glycosidic groups were found in both techniques by FTIR analysis. Extracts of the dried peel powder showed higher TPC in VOD (506.33 mg GAE/100g) against TD (458.33 mg GAE/100g), indicating better retention of phenolic constituents during drying. GC-MS analysis highlighted a diverse volatile profile with VOD retaining additional bioactive components such as hydroquinone, DDMP and catechol which have potential antioxidant activity, in addition to dominant furan derivatives. Overall, the findings showed that VOD is more efficient in maintain the functional and phytochemical*

properties of jaboticaba peel powder, suggesting its potential use in functional foods and nutraceutical products.

KEYWORDS: Jaboticaba peel; Vacuum Oven Drying; Tray Drying; FTIR; Phenolic compounds; GC-MS

INTRODUCTION

India faces food security issues with a population of 1.38 billion, further aggravated by post-harvest losses and the underutilization of emerging fruits [1], [2]. Common fruits such as mango, banana, apple and guava cover 72% of the land used for cultivation, while indigenous fruits such as Jamun (***Syzygium cumini***), Kokum (***Garcinia indica***), Indian Jujube (***Ziziphus mauritiana***) etc. occupy only 6.58%, although they possess higher nutritional values [3]. Jaboticaba (***Plinia cauliflora***), a native fruit to South America and recently introduced in the southern parts of India (Kerala, Karnataka, Maharashtra, and Telangana) has great potential for bioactive compounds. The fruit' s peel, pulp and seeds are rich in anthocyanins (cyanidin-3-glucoside), ellagitannins, phenolics with antioxidant, antimicrobial, and anti-inflammatory properties [4], [5], [6], [7].However, its high moisture content (81.2-86.9%) and monosaccharide concentration (fructose 3,5-6.8 g/100g, glucose 4.2-5.9 g/100g, sucrose 1.2-2.8 g/100g) make it susceptible to spoilage and fermentation in 2-4 days [8], [9], [10].

Drying is a common preservation technique for fruit products that lowers water activity to extend shelf life, as it inhibits microbial growth, slows down degradative reactions and concentrating valuable bioactive constituents [11]. However, selection of the drying method and operating conditions significantly impacts not only residual moisture and colour but also the retention and modification of phenolic compounds and volatile constituents[11], [12], [13], [14]. Previous studies on jaboticaba were mainly related to drying flakes in convectional drum drying and production of peel flours, some of which have emphasized on anthocyanin, phenolics and pectin recovery[8], [9], [10], [15], [16], [17], [18], [19]. However, limited information is available about the effects of vacuum drying methods on the physicochemical properties, mineral composition, functional group profile and volatile compounds of jaboticaba peel powder

Thus, the objective of the present study was to compare the drying processes of tray drying (TD) and vacuum oven drying(VOD) (at 50±2 °C)on the moisture content, colour attributes, mineral composition, FTIR characteristics, total phenolic content and GC-MS volatile profiles on peel powder

MATERIALS AND METHODS

SAMPLE PREPARATION: - Fresh ripe jaboticaba fruits were collected from the Ex-Situ Biodiversity Park, University of Horticultural Sciences, Bagalkot Campus, Bengaluru. Collected fruits were washed with running tap water, disinfected with 1% sodium hypochlorite (v/v), and rinsed with distilled water

three times. The peels were removed from fruit using a stainless-steel knife, blotted with filter paper to remove excess moisture from the fruit surface, and prepared for further processing [20].

a

b

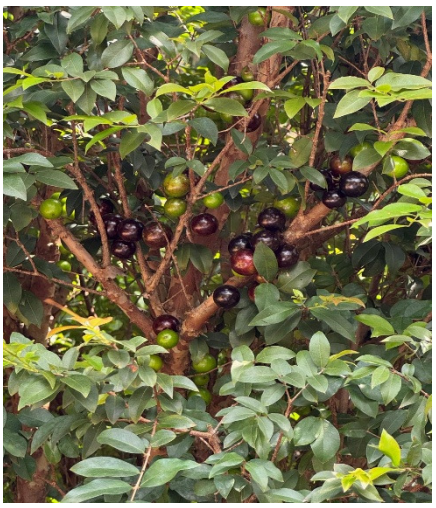


Fig 1: Jaboticaba fruits (***Plinia cauliflora***) used in the study: (a) close – up of ripened fruits; (b) fruiting tree with various maturity stages

DRYING TREATMENTS

TRAY DRYING (TD): The fresh peels were uniformly placed on the perforated stainless-steel trays and dried in a laboratory tray dryer (Isotech Technology Pvt. Ltd., Model ITDCT-150 RE SPL) at 50±2 °C for 18 hours until a constant weight was achieved (final moisture <10%wet basis)[21]. After drying, the samples were cooled at room temperature, ground in a laboratory grinder, sieved through a 500 µm screen, and then stored in metallized polyester pouches at 4 °C until analysis.

VACUUM OVEN DRYING (VOD): The peels were evenly placed on trays and dried in a vacuum oven (REMI, Model RV0-50) at 50 ± 2 °C and 97 kPa for 12 hours, until a constant weight was attained (final moisture <10%wet basis). The dried samples were cooled, ground, sieved, packaged, and stored as per the TD protocol[22].

MOISTURE CONTENT DETERMINATION

The moisture content of dried jaboticaba peel powder, on a wet basis, was determined using the hot air oven (Vasa Scientific Co., Model HAO-24-200) method at 105±3 °C for 24 hrs, as described by AOAC 930.15 (Association of Official Analytical Chemists) procedure. Studies have shown that dried fruit products with moisture content of less than 10% are appropriate for handling, processing, transport, and storage, as this level checks the growth of microbes and stop unwanted biochemical reaction[23].

$$Moisture\ \%\ (wb) = \frac{W_1 - W_2}{W_1} \times 100$$

Where W1:Intial (wet) mass, W2: Oven- Dried mass

COLOUR ANALYSIS

The colorimetric coordinates L*, a* and b* were measured using a Sensegood SpectroPro spectrophotometer under D65 illumination and a 10 °viewing angle. In this color system, L* represents lightness (0 = black, 100 = white), while a* and b* represent the chromaticity coordinates (+a* = red, −a* = green; +b* = yellow, −b* = blue). The jaboticaba peel powder was placed in the sample cup to obtain a flat surface, and the instrument was then calibrated with black and white standards. After that, three replicate measurements were randomly taken in different regions of the sample cup, and the average values ± SD of L*, a*, and b* were used for the color differences obtained between the drying treatments[16].

MINERAL ESTIMATION

Mineral analysis for calcium (Ca), iron (Fe), and magnesium (Mg) was performed using [24] guidelines. About 1.0 g of dried jaboticaba peel powder was subjected to wet digestion using a 4:1 (v/v) mixture of concentrated nitric and perchloric acids. Atomic Absorption Spectrophotometry (Agilent, Model 240FS AA) was used to determine the minerals at their characteristic wavelengths: Ca at 422.7 nm, Fe at 246.3 nm, and Mg at 285.2 nm, using calibration curves based on certified reference materials at 1,2,5, and 10 mg/L. Data as expressed as mg/kg of dried matter [25].

FOURIER TRANSFORM INFRARED SPECTROSCOPY

The Fourier – transform infrared (FTIR) spectroscopy was used to analyze the chemical composition and functional groups of the samples. The analysis was carried out using a Perkin Elmer FTIR spectrometer (Model: Spectrum Two). All Spectra were obtained in the mid- infrared region (4000- 450 cm^{-1}) by using the potassium bromide (KBr) pellet in ambient conditions. The spectra were baseline-corrected and normalized in order to reduce the variability of the measurements. The band frequencies (or wavenumbers) were determined from the spectra and assigned to their corresponding functional groups, based on literature reports, and provide an indication of the presence of particular functional groups within the samples [9], [10], [26].

MACERATION EXTRACTION

Three grams of jaboticaba peel powder was dispersed in 60 ml of 50 % aqueous ethanol (v/v) (1:20 solid: solvent ratio). The extraction was performed at ambient temperature under continuous stirring (200 rpm) using a magnetic hotplate stirrer (Abdos Labtech Pvt. Ltd, Cat No. E11231) for approximately 15 mins for three consecutive cycles until a clear filtrate was obtained. Each cycle had the mixture filtered through Whatman no 1 filtered paper following completion of maceration. The filtrates from the three cycles were combined and concentrated using a rotary evaporator (Hahnvapor, Model HS-2005V) at 45 °C

under reduced pressure until a viscous concentrated extract was obtained, which was subsequently stored at -20 °C until further analysis[27], [28].

TOTAL PHENOLIC CONTENT DETERMINATION

The phenolic content was determined based on Folin-Ciocalteu assay (FCR), using gallic acid (Loba Chemie Pvt Ltd, Mumbai) as the calibration standard. A 0.5 ml sample extract was mixed with 0.3 mL of Folin Ciocalteu reagent and 2 ml of 20% sodium carbonate and the volume was adjusted to 6.5 mL with distilled water. the absorbance of the mixture was measured at 765 nm using a spectrophotometer (model) after incubation of 2 hours at room temperature and in darkness. The amount of gallic acid was subsequently determined based on the gallic acid standard curve and expressed in terms of mg gallic acid equivalents per hundred grams of sample (mg GAE/100g)[29].

PREPARATION OF PEEL EXTRACTS FOR COMPOUND QUANTIFICATION BY GC-MS

Gas chromatography- mass spectrometry (GC-MS) analysis of jaboticaba dried peel extracts was carried out using Shimadzu QP2020 series gas chromatograph equipped with 30m × 0.25 mm × 0.25 µm SH-Rxi-5Sil capillary column. Helium was the carrier gas used at a constant flow rate of 1.20 mL/min; and maintained at constant pressure held at 68.3 kPa. The injection volume was 1.0 µL, and the split ratio was 1:50. A flame ionization detector (FID) was set to 320°C. The temperature program consisted of holding the initial temperature (50° C) for 2 minutes; then increased at 10°C/min to 230° C; increased further at 15° C/min to 330° C; and held for a total of 5 minutes. Identification of compounds was made by computer assisted comparison of the acquired mass spectrum with commercial reference spectrum libraries found in the instrument software[30].

Each measurement was replicated and is reported as mean± standard deviation. No statistical hypothesis testing was performed and the results are reported as descriptive statistics.

RESULTS AND DISCUSSION

MOISTURE CONTENT AND COLOUR ANALYSIS

The moisture contents of tray dried (TD) and vacuum oven dried (VOD) jaboticaba peel powders were 7.66±0.02 % and 6.29±0.05 %, respectively (Table 1). Both moisture contents fall withing the acceptable range for commercial powders for processing and storage [17], confirming that both these techniques effectively removed moisture to prevent microbial growth and enzyme activity .These findings are consistent with other studies on jaboticaba peel showing 5-8 % moisture after drying with convective drum drying [18].The VOD samples had lower moisture levels than TD probably due to the more efficient moisture transfer from the sample to air (enhanced by reduced pressure) and from the use of lower drying temperatures (40-60°C) [10]. Since the convective heat transfer and air current used in tray drying may lead to high residual moisture, VOD is a better strategy to reach the optimum moisture contents for longer shelf life [12].

The colour attributes were evaluated using the CIELAB system, and presented in Table 1. The L * values for TD (36.36±0.01) and VOD (35.11±0.03) fall within range established for conventionally oven-dried jaboticaba peels (19.78-40.23 L* units) (Resende et al., (2020) confirming the characteristics dark appearance attributed to pigment concentration and melanoidin formation. For both drying methods, the a* and b* chromatic values were similar to those of drum dried jaboticaba flakes ([19] with the a* values being higher and more positive than the b* values because of anthocyanin preservation, however the apparent pattern of chroma development was different between the two drying methods adopted. Specifically, VOD samples demonstrated higher a*(15.19±0.03) and lower b*(6.86±0.16) than TD samples a* (13.68±0.02) and b* (9.31±0.13).

These variations are due to the operational differences of each drying method. Vacuum oven drying applies low pressure and low temperatures (40-60 °C) will help retain heat sensitive anthocyanins while slowing down non-enzymatic browning. However, tray drying uses convective heating and greater oxygen availability which leads to loss of red pigments, and Maillard reactions between reducing sugars and amino acids. This ultimately leads to the formation of yellow brown melanoidins that increased the b* value. Thus, vacuum oven drying resulted in better colour preservation [12].

TABLE 1. PHYSICOCHEMICAL PROPERTIES OF DRIED JABOTICABA PEEL POWDERS

PARAMETERS	TD	VOD
MOISTURE	7.66 ± 0.02	6.29 ± 0.05
L*	36.36 ± 0.01	35.11 ± 0.03
a*	13.68 ± 0.02	15.19 ± 0.03
b*	9.31 ± 0.13	6.86 ± 0.16

* Values are Mean±SD (n=3). L*: Lightness, a*: Red to Green, b*: Blue to Yellow

MINERAL COMPOSITION OF TRAY DRIED AND VACUUM OVEN DRIED PEELS

The drying operations affected the mineral composition of jaboticaba peel powder, resulting in significant differences in the amounts of calcium, iron, and magnesium (Table 2). The elemental compositions of these minerals after drying revealed that calcium was relatively constant at 1100 mg/kg for both drying procedures i.e. tray drying and vacuum oven drying, which showed that drying procedure did not affect the calcium content significantly. However, iron content was more variable, with tray drying resulting in 70±0.04 mg/kg, which was significantly lower than 150±0.05 mg/kg obtained by vacuum oven drying, which may be attributed to low oxygen environment that could have contributed to the retention or concentration of iron. Magnesium content was also different, with 2500±0.08 mg/kg for tray drying and 1500±0.06 mg/kg for vacuum oven drying. During tray drying, moisture is removed from the sample resulting in the density of the remaining solid material becoming very dense. Therefore, tray dried sample had higher magnesium content compared to vacuum oven dried[31].

The mineral content of the dried powders was significantly enriched compared to the fresh 'Sabara' variety that contained 78.44 mg/kg calcium, 2.21 mg/kg iron and 119.06 mg/kg magnesium[8]. This is mainly due to the water loss during the drying process, which causes concentration of solid matter and increase in the mineral per unit of dry matter[12]. In addition, although both drying methods successfully increased these minerals, the unique heat and mass transfer processes involved has resulted in differences in mineral content.

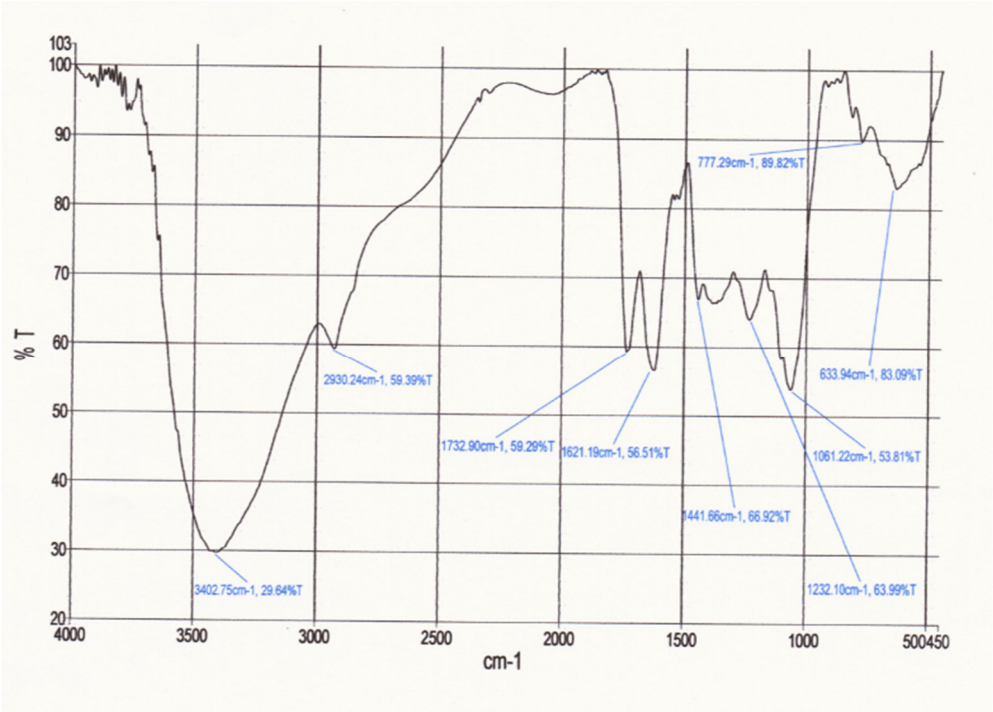
TABLE 2. MINERAL COMPOSITION OF JABOTICABA PEEL POWDER USING VARIOUS DRYING TECHNIQUES (mg/kg)

PARAMETER	TD	VOD
Calcium (mg/kg)	1100±0.05	1100±0.04
Iron (mg/kg)	70±0.04	150±0.05
Magnesium (mg/kg)	2500±0.08	1500±0.06

*Mean±SD, n=3

FOURIER TRANSMISSION INFRARED SPECTRA

A



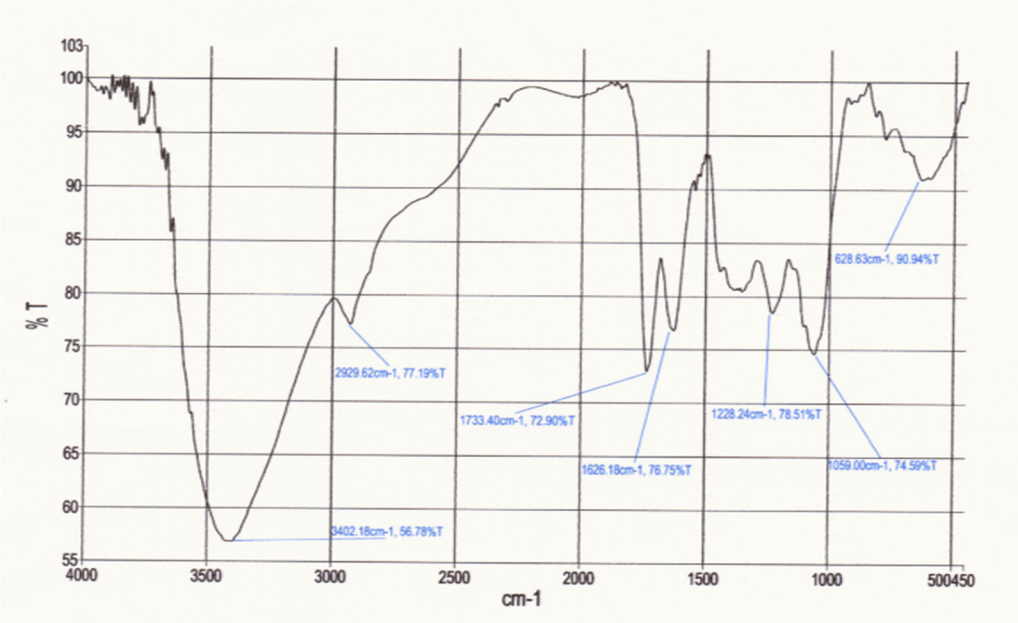


Fig 2: Fourier-Transform Infrared Spectra of Jaboticaba Peel: Comparison of Tray Dried (A) and Vacuum Oven Dried (B)

The Fourier- transform infrared (FTIR) spectra of jaboticaba fruit peels obtained from TD and VOD are presented in Fig 2. , revealed a similar overall profile retaining the same major functional groups under both drying methods. All powders exhibited a broad absorption band broad around 3400 cm^{-1} corresponding to stretching vibrations of O–H groups of water, phenolics or polysaccharides [32]. This band was more intense in the tray dried (TD) samples, indicating presence water or hydroxyl groups as compared to the vacuum oven- dried (VOD) samples [13]. At 2930 cm^{-1}, both drying methods produced a C-H stretch attributed to phenolic structures[33]. Strong peaks at 1733-1623 cm^{-1} are due to C=O stretching vibrations, revealing functional groups bearing carbonyl groups, including amides, aldehydes, ketones, carboxylic acids and benzopyran rings [33], [34]. The TD powders specifically had a band at 1441 cm^{-1} that is attributed to C=C stretching from aromantic rings and conjugated alkenes. Additionally, C-O stretching bands in the 1232-1228 cm^{-1} region specify stretching vibrations pf pyran ring flavonoids or aryl esters [34], [35], [36]. The TD samples exhibited the most intense peak in the 1061-1059 cm^{-1} region indicating the presence of glycosidic linkages (C-O-C stretching) [32]. The bands absorbance in a region below 1000 cm^{-1} (777-779 and 633-634 cm^{-1}) confirm the presence of aromatic rings [34], [35]. Overall, the FTIR results show that the processing technique can have a significant impact on the retention of chemical groups that have potential bioactivity.

TOTAL PHENOLIC CONTENT

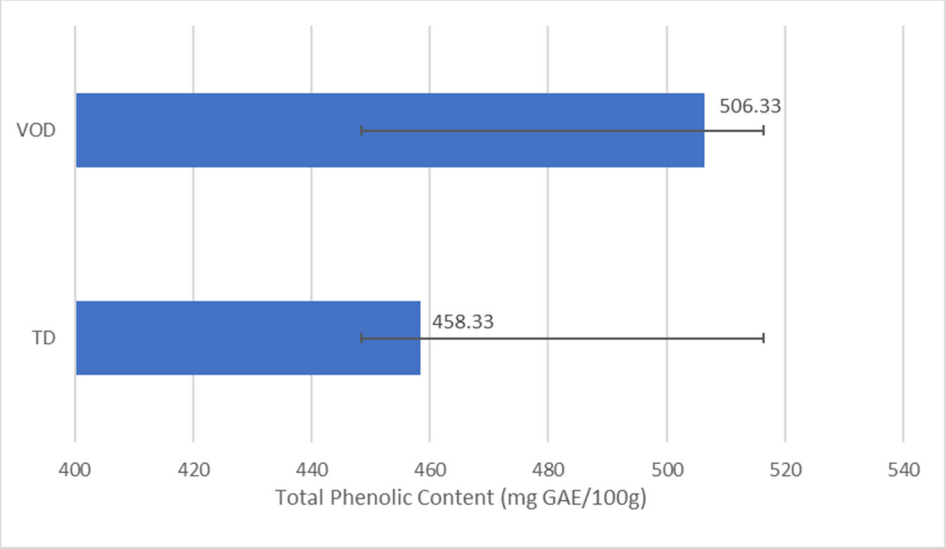


Fig 3: Quantitative difference between the total phenolic content (TPC) of TD and VOD jaboticaba peel extracts

The total phenolic content in extracts obtained by both tray drying (TD) and vacuum oven drying of jaboticaba peels is shown in Fig 3. The VOD extract showed higher TPC (506.33±0.27 mg GAE/100g) than TD extract (458.33±0.05 mg GAE/100g) which indicates the recovery of the phenolic compounds was more efficient with VOD. This increase indicate that the VOD method was effective to increase the percolation of the solvent in the cell wall and accelerate the liberation of the phenolics from the peel matrix[27]. Additionally, the increased phenolic retention in VOD might be due to less oxygen contact and lower thermal stress when drying, which could help to reduce the extent of oxidative degradation of phenolics[14]

This observation is similar to that of Nunes et al., (2020), who reported 2697.59 mg of gallic acid/100 g dry basis of drum dried jaboticaba flakes. While such direct numerical comparison is limited by differences in sample form, extraction route, and expression basis, both studies indicate the high phenolic content of jaboticaba-based materials and the strong influence of processing conditions upon both phenol retention and extractability.

Overall, the VOD drying method presented better recovery of phenols in the jaboticaba peel that the TD treatment.

GCMS PROFILES OF TRAY DRIED AND VACUUM OVEN DRIED EXTRACTS

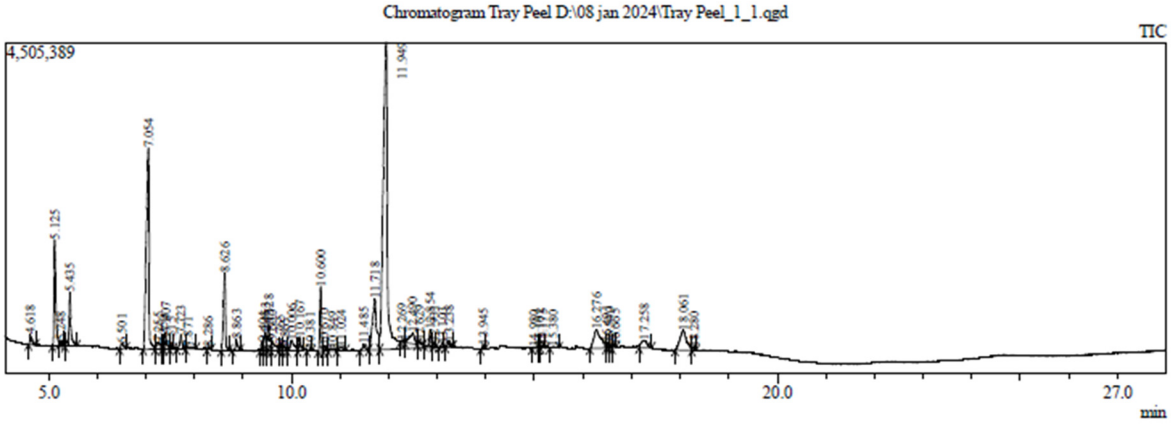


Fig 4: GC–MS Profile (Total Ion Chromatogram) of the Tray-Dried Extract

The total ion chromatogram of tray- dried jaboticaba peel extract (Fig 4), showed a complex profile consisting of 50 compounds identified by GC-MS (Table S1). The principal peaks correspond to 5-Hydroxymethylfurfural (HMF; 37.36 % relative area at R. Time 11.949 min), 2,5-furandione, 3-methyl (15.15% at R. Time 7.054 min), furfural (5.14% at R. Time 5.125 min), and malic acid (5.89 % at R. Time 11.718 mins).

Other prominent compounds included maltol (1.08 % at R. Time 9.463 min), thymol (0.40 % at R. Time 11.024 min) and D-allose (3.53% at 16.276 min), in addition to minor terpenes and esters. Furan derivatives (HMF, furfural) along with anhydrides such as 2.5-furandione, were the most abundant compounds found in tray dried extracts

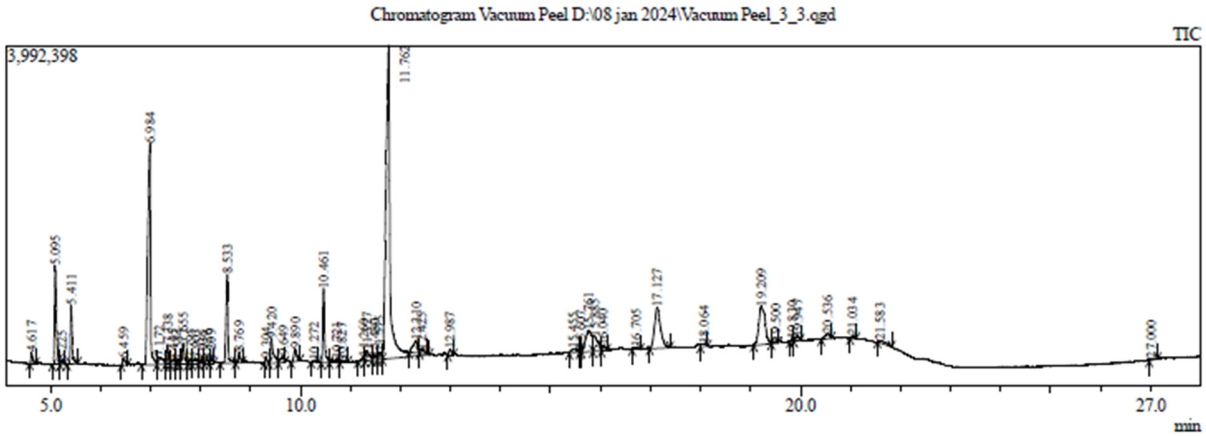


Fig 5: GC–MS Profile (Total Ion Chromatogram) of the Vacuum Oven Dried Extract

Similarly, the total ion chromatogram of vacuum oven-dried jaboticaba peel extract (Fig 5) showed the presence of 50 compounds identified by GC-MS analysis (Table S2). The leading peaks were 5-Hydroxymethyfurfural (HMF) (32.89% relative area at R. Time 11.762 min), 2,5-Furandione, 3-methyl-

(14.79 % at R. Time 6.984 min), 1,6-Anhydro-. alpha. -d-galactofuranose (6.19% at R. Time 17.127 min), and Kaur-16-en-18-ol, (4. alpha.)- (6.01 % at R. Time 19.209 min).

Additional key compounds identified included 4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-(DDMP) (3.41% at R. Time 10.461 min), hydroquinone (0.40% at R. Time 12.425 min), catechol (0.36% at R. Time 11.260 min), and D-allose (5.29% at R. Time 15.761 and 15.885 min), as well as traces of terpenes and esters. Anhydrides (2,5- furandione series approximating 21% of the area) and aldehydes (notably HMF and furfural at 4.67%) were the main classes of compounds in the vacuum oven dried extract.

The GC-MS analysis presented in Tables S1. And S2. identified the volatile profiles of tray dried and vacuum oven dried jaboticaba peel extract with 50 compounds in each treatment, showing a number of similarities and differences in abundance. The compounds occurring both treatments were collated and summarized in Table 3. as common chemical markers. Among the shared constituents, 5-Hydroxymethylfurfural (HMF) was dominant in both profiles at 37.76% in TD and 32.80% in VOD, respectively, contributing anticarcinogenic, antioxidant, and anti-apoptic properties [37]. HMF, which is a Maillard product, attained a relatively lower prevalence in the case of VOD samples, indicating moderated thermal degradation under vacuum conditions[38]. Another compound that showed consistency with anticancer activity (R. Sai Nandhini, 2021) in both drying methods is 2,5-furandione, 3-methly-, with 15.98% and 15.81% respectively. Furfural (TD: 5.14%, VOD: 4.67%) provided antibacterial potential [39]. D.allose imparted anti-inflammatory and anti-proliferation activities, and it was remarkably preserved, irrespective of the drying method employed[40], [41].

Further analysis of the common show's complex patterns of retention of biological activity. 4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-(DDMP) (TD: 2.82%; VOD: 3.41%) showed increased antioxidant activity in VOD extracts [42], suggesting that low-pressure conditions favor the maintenance of antioxidant function. Maleic anhydride (TD: 2.71%; VOD: 2.53%) and furyl hydroxymethyl ketone (TD: 1.55%: VOD: 1.71%) have potential anti-bacterial and anti-fungal activity with slight improvement in VOD conditions [43], [44]. Butanedioic acid, methylene – (both: 1.48-1.49%) showed consistent anti-inflammatory and anti-bacterial properties [45]. Phenolics like hydroquinone (TD: 0.24%; VOD 0.40%) showed better retention in VOD extracts showing antioxidant and anti-inflammatory properties [46], [47]. Catechol (TD: ND: VOD: 0.36%) emerged exclusively in VOD with antimicrobial and antioxidant properties [48], [49]. Trace compounds like decanoic acid, 3-methyl- (TD: 0.34%; VOD: 0.40%) and pentanoic acid, 4-oxo- (approximately 0.55%-0.56% for both) showed antibacterial activity(Shen et al., 2021; Shinde, 2025). While 2-amino-1,3,5-triazine which is a derivative of 1,3,5-triazine (TD: 0.10%: VOD: 0.24%) showed promising anticancer leads [52]. Several of the above compounds are known to exhibit antioxidant, antimicrobial and anticancer- related activity in the literature; however, the results obtained in the GC-MS analysis are tentative identification and relative peak areas only. Therefore, these activities should be regarded as potential bioactivities and can be validated only by conducting direct

bioassays with the current extracts. Overall, the findings suggest that vacuum oven drying is more desirable drying method for maintaining various phenolic compounds.

TABLE 3. COMPARATIVE ANALYSIS OF MAJOR COMPOUNDS IN TRAY-DRIED AND VACUUM-DRIED JABOTICABA PEEL EXTRACT

Sl No	Name	TD Area %	VOD Area %	Biological Activity	References
1	5-Hydroxymethylfurfural (HMF)	37.76	32.80	Anticarcinogenic, Antioxidant and Anti-apoptotic	[37]
2	2,5-Furandione, 3-methyl-	15.98	15.81	Anticancer	[53]
3	Furfural	5.14	4.67	Antibacterial	[39]
4	D-Allose	3.53	3.47	Anti-inflammatory, Anti-proliferation	[40], [41]
5	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-(DDMP)	2.82	3.41	Antioxidant	[42]
6	Maleic Anhydride	2.74	2.53	Anti-bacterial & Anti-fungal	[43]
7	Furyl hydroxymethyl ketone	1.55	1.71	Anti-microbial	[44]
8	Butanedioic acid, methylene -	1.48	1.49	Anti-Inflammatory, Anti-bacterial	[45]
9	2-Furancarboxaldehyde, 5-methyl-	0.93	1.01	Anti-microbial	[54]
10	2,4-Dihydroxy-2,5-dimethyl-3(2H)-furan-3-one	0.89	1.32	Antioxidant, Anti-bacterial and Anti-cancer agent	[55]
11	Hydroquinone	0.24	0.40	Antioxidant, Anti-inflammatory	[46], [47]
12	Catechol	ND	0.36	Anti-microbial, Anti-oxidant	[48], [49]
13	Decanoic acid, 3-methyl-	0.34	0.40	Antibacterial	[56]
14	Pentanoic acid, 4-oxo-	0.56	0.55	Anti-microbial	[51]
15	2,5-Furandicarboxaldehyde	0.42	0.31	Bio Based Cross linking	[57]

16	1,6-Anhydro-. alpha. -d-galactofuranose	0.30	6.19	No recorded activity	NA
17	2-Amino-1,3,5-triazine	0.10	0.24	It is a derivative of 1,3,5-triazine and has potential anti-cancer	[52]
18	Cyclopentanone, dimethylhydrazone	0.15	0.23	NA	NA

*NA – No Recorded Activity

CONCLUSION

The compositional and bioactive quality of jaboticaba peel powder was significantly affected by the drying method used. The results of this study indicated that VOD had the lowest residual moisture, better colour retention, and a higher level of phenolic preservation than TD indicating that heat-sensitive compounds are stabilized under reduced oxygen conditions. Powders obtained in both drying processes retained significant functional groups. VOD exhibited superior retention of bioactive compounds associated with potential antioxidant and antimicrobial activity compared to TD. GC-MS data additionally revealed changes in the relative abundances of major volatile compounds including furan derivatives and phenolic-related compounds. In conclusion, the results of this study indicated that the bioactive potential of jaboticaba peel is preserved better by vacuum oven drying, but this should be further validated by replicating the experiments and applying statistical methods.

FUTURE COURSE WORK

Future studies should focus on the comparison of freeze-drying techniques between tray drying and vacuum oven drying methods, optimizing the variables using response surface methodology to improve color, mineral content, and bioactive compounds, particularly anthocyanins and phenolics. In vitro antioxidant activity (DPPH and FRAP) and antimicrobial activity, as well as HPLC analysis of phenolics content, will be used to validate functional properties. In addition, microencapsulation methods (spray drying, coacervation, and liposomal encapsulation) may also be investigated using biopolymeric wall materials (maltodextrin, gum arabic, and chitosan) to protect anthocyanins, furan derivatives, and phenolics.

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