

Impact of Different Drying Method on Phytosterols and Proximate Biochemical Contents in Leaf, Stem and Root of Jivanti [*Leptadenia reticulata* (Retz.) Wight and Arn.]

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Abstract

Leptadenia reticulata (Retz.) Wight & Arn., is commonly known as jivanti is extensively used to treat various diseases from an ancient time. Effect of different drying method (sun, shade, vacuum, oven, tray, microwave continuous, microwave vacuum and fluidized bed dryer) on phytosterols and proximate biochemical parameters content in different plant parts of jivanti was assessed. LC-MS analyzed showed that significantly maximum campesterol, CAM in shade drying (5.10 µg/g) while stigmasterol, STIG (12.03 µg/g) and β -sitosterol, β -SIT (17.93 µg/g) were found maximum in vacuum drying. Among the plant parts, leaves exhibited relatively maximum content of β -SIT (37.47 µg/g), STIG (21.52 µg/g) and CAM (7.85 µg/g) compared to stem and root. All the drying methods resulted in drastic reduced in moisture content; reducing sugar (4.55 %), fibre (44.61 %), ash (16.23 %), flavonoid (5.92 %), antioxidant activity, AOA (0.71 %) and total phenol, TPHC (0.83 %) content was found significantly maximum retention in vacuum drying. However, shade drying was revealed maximum conservation of chlorophyll (23.26 mg/ g), carbohydrate (14.80 %), protein (13.47 %), non-reducing sugar (11.04 %) and TSS (14.14 %). A positive correlation of AOA with TPHC, CAM, STIG and β -SIT was recorded. Vacuum drying contributed maximum (56.18 %) variation followed by shade drying (12.26 %) in principal component analysis (PCA). Considering all these points, vacuum drying techniques could be used to dry the jivanti leaves to get maximum retention of phytochemical compounds.

Highlights

- Different drying methods furnished a significant impact on the quality of dried jivanti
- Vacuum drying method showed maximum retention of phytosterols and proximate biochemical contents
- Higher concentration of β -sitosterol was obtained followed by stigmasterol and campesterol in jivanti
- Dried jivanti leaves showed maximum phytosterols contents than stem and root
- In dried jivanti leaves, 37.47 µg/g of β -sitosterol was retained

1. Introduction

Leptadenia reticulata (Retz.) Wight and Arn. belongs to the family Asclepiadaceae and it is climbing in nature, commonly known as Jivanti, Swarnjivanti, or Dodi. It is found to be an important plant in ethnobotanical studies. Jivanti especially improves the metabolism, digestive system and enhances the health status of the body (Bawra et al., 2010) and it is considered to be a Rasayana which is included among the 10 drugs constituting the 'Jvaniya gana' and 'Vitalizing group' (Sivaranjan and Balachandran, 1994).

The accumulation of active phytochemicals compound varies within the plant parts and it is associated with the number of factors including geographical topography, agro climatic conditions, growing behaviour and methods of harvesting and drying process. The preliminary qualitative tests have shown the occurrence of terpenoid, sterols, tannin, saponin, flavonoids, carbohydrates and glycosides in aerial parts of jivanti (Pal et al., 2012). Jivanti leaves contains moisture (6–7%), nitrogen (17.5%), ash (5.5–6.5%), insoluble ash (0.1%), calcium (0.6%), sodium and potassium calculated as chlorides in the range of 2.16–2.24% (Verma and Agarwal, 1962). Further it was revealed that leaves contain a bitter neutral principle, albuminous, Ca-oxalate and tartaric acid (Sastry et al., 1985). The fruits of this plant contain quercetin, isoquercetin, rutin and hyperoxide while the seed contain meso-inositol and mono methyl ether (Bawra et al., 2010). Krishna et al., 1976 found that leaves and twigs content α -myrin, β -myrin, luteolin, diosmetin, rutin, β -sitosterol, stigmasterol, hentriacontanol, a triterpene alcohol simiarenol, apigenin. The medicinal importance of this plant is due to the presence of such various principal ingredients in various plant parts and reported to use in numerous ailments. Among the phytochemical compounds present in jivanti, phytosterols are very important on account of its antioxidant in nature (Yoshida and Niki, 2003) and it is very similar to cholesterol in their chemical structure. Resulting, phytosterols have the property to inhibit the cholesterol absorption in body and widely used as food supplements to check the cardiovascular disorders and dyslipidemia (Gupta and Prakash, 2014). Most extensive phytosterols found in nature are campesterol, stigmasterol and β -sitosterol and normally used in the diet. Overall, jivanti plant works as an anti-depressant activity, vasodilator activity, anti-anaphylactic effect, anti-abortifacient activity, oligospermic activity, anti-cancer activity, cardiovascular activity, galactagogue activity, anti-implantation activity, antimicrobial activity (Bawra et al., 2010).

The physical and chemical properties of medicinal and aromatic plants are determined by their moisture content. The first step in many postharvest operations is the removal of moisture that is, drying. So, drying is the technique of an applying heat that remove the moisture which increases the shelf life of the products by checking the certain biochemical reactions and decelerating the growth of microorganism's eventually that reflects to the final properties of the products (Ghasemi et al., 2013). For this, adequate dryers are needed, such as temperature, velocity and humidity that provide a rapid reduction in the moisture content without affecting to active ingredients of medicinal plants with respect to the drying period (Rocha et al., 2011). The choice of optimal drying temperature, duration and nature of drying is the central economic and ecological principle during the drying. Several changes has been occur in the plant products based on the methods and conditions of drying applied and which may induce formation of new compounds having remediation properties (Kubra and Rao, 2012; Rahimmalek and Goli, 2013; Mirhosseini et al., 2015). Conventional drying techniques (sun and shade drying) have been popularly used for drying of food materials (Shitanda and Wanjala, 2006). However, sensitive phytochemicals compounds can easily degraded during the drying due to extensive contact to oxygen and/or unregulated sunlight temperature, but one of the very positive point is that these conventional techniques are very economic (Vega-Galvez et al., 2009; Nguyen et al., 2015). Besides this, vacuum, hot air, freeze, fluidized bed, microwave and low-pressure drying methods are very promising techniques in present scenario in different crops. Some works have also been reported that advanced drying techniques like microwave drying, fluidized bed-drying and hot air drying showed less drying time with uniform energy distribution and high thermal conductivity which yield in high quality product as compared to conventional drying techniques (Ozkan et al., 2007). By considering all these points, the present investigation was framed in order to find out the most efficient drying techniques for jivanti crop with respect to the different plant parts in terms of restoration of medicinal and other quality parameters of the plant.

2. Materials and Methods

2.1 Plant Materials

The fresh jivanti plant was collected at 90 days after transplanting from the field of Medicinal and Aromatic Plants Research Station, Anand Agricultural University, Gujarat. All the three plant parts (leaf, stem and root) were separated and washed thoroughly with running water to remove all dirt. Then it was wiped with muslin cloth to remove surface water. One kilogram each of plant parts were used for each drying process in triplicate replication (Fig. 1).

2.2 Drying Processes

Leaf, stem and root were subject to the different drying methods and their details conditions are given in Table 1. The physical appearances of dry powder are shown in Fig. 2.

Table 1
Conditions of Different Drying Methods Adopted During the Drying Processes

Drying method (D)	Drying conditions	Plant part (P)	Drying period
D1: Sun drying	Temp. : 38 °C ± 2 °C Relative humidity : 60–70%	P1: Leaves	35 hrs daylight (5 days)
		P2: Stems	42 hrs daylight (6 days)
		P3: Roots	70 hrs daylight (10 days)
D2: Shade drying	Temp. : 30 °C ± 2 °C Relative humidity : 75–85%	P1: Leaves	6 days
		P2: Stems	13 days
		P3: Roots	15 days
D3: Vacuum drying	Temp. : 45 °C ± 2 °C Absolute pressure : 3–5 kPa	P1: Leaves	17 hrs.
		P2: Stems	19 hrs.
		P3: Roots	22 hrs.
D4: Oven drying	Temp. : 45 °C ± 2 °C	P1: Leaves	5 hrs.
		P2: Stems	6 hrs. 30 min
		P3: Roots	23 hrs. 30 min.
D5: Tray drying	Temp. : 45 °C ± 2 °C	P1: Leaves	10 hrs.
		P2: Stems	19 hrs.
		P3: Roots	22 hrs.
D6: Microwave continuous drying	Temp. : 45 °C ± 2 °C Belt speed : 3	P1: Leaves	1hrs. 30 min.
		P2: Stems	3 hrs. 45 min.
		P3: Roots	6 hrs.
D7: Microwave cacuum drying	Temp. : 45 °C ± 2 °C Magnetron power : 4 kW/hr	P1: Leaves	1 hrs. 15 min.
		P2: Stems	10 hrs.
		P3: Roots	12 hrs.
D8: Fluidized bed drying	Temp. : 45 °C ± 2 °C Air velocity : 15-16.2 m/sec	P1: Leaves	3 hrs.
		P2: Stems	10 hrs. 30 min.
		P3: Roots	11 hrs.

2.3 Chemicals and Instruments

Dimethyl sulphoxide (DMSO), phenol crystal (C₆H₆O), sulphuric acid (H₂SO₄), methanol (CH₃OH), anhydrous glucose (C₆H₁₂O₆), molybdcic acid (MoO₃ H₂O), nitric acid (HNO₃), anhydrous aluminium chloride (AlCl₃), potassium acetate (CH₃CO₂K), 2,4,6-tris(2-pyridyl)-s-triazine (TPTZ), folin-ciocalteu's reagent (FCR), mercury oxide (HgO) were procured from the Sigma Aldrich Fine Chemicals (St. Louis, MO, USA) for the various biochemical analysis as per the procedure. Furthermore, hydrochloric acid (HCl), anhydrous sodium carbonate monohydrate (CH₂Na₂O₄), potassium sulphate (K₂SO₄), anhydrous copper sulphate (CuSO₄), sodium hydroxide pellets (NaOH), boric acid (H₃BO₃), sodium carbonate (Na₂CO₃), methyl red bromocresol green pH indicator (MRBC), tannic acid

powder and quercetin dehydrate were purchased from the HiMedia. The lists of instrument/equipment used in drying and analysis are given in supplementary Table 1.

2.4 Estimation of Phytosterols: Campesterol (CAM), Stigmasterol (STIG) and β -Sitosterol (β -SIT) through LC-MS

All the three phytosterols present in leaf, stem and root were determined by following the protocol given by Lee et al. (2015) with some modification. All the chemicals used in the phytosterols analyzed were LC-MS grade standard.

2.5.1 Standard preparation

Analytical grade standard of campesterol (CAM), stigmasterol (STIG) and β -sitosterol (β -SIT) were procured from Sigma-Aldrich Fine Chemicals (St. Louis, MO, USA). Standard stock solution of CAM was prepared in 2% DMSO in 80% methanol, while STIG and β -SIT were prepared in 80% methanol and stored at below 4°C. The working standard solutions in the range of 0.01-1.0 μ g/g were prepared by appropriate dilution of stock solutions with methanol. These diluted working solutions were used for establishment of calibration curves.

2.5.2 Sample extraction

Leaves: 1 g homogenized sample was extracted with 80% methanol and ethyl acetate (50:50) along with 50 mg charcoal and 1 g of $MgSO_4$. The solution was thoroughly mixed through vortex followed by centrifuged at 6000 rpm for 10 min. 1 mL aliquot was diluted with methanol up to 100 times, filtered through 0.22 μ m syringe filter and it was used for downstream analysis.

Stems

Same as the sample preparation of leaves deprived of addition of charcoal.

Roots

1 g homogenized sample was extracted with 20 mL ethyl acetate followed by centrifuged at 6000 rpm for 10 min. From this, 5 mL aliquot was undergoes evaporation near to dryness using TurboVap® under gentle stream of N_2 at 45°C. Final volume was made up to 1 mL with 100% methanol. Dilute the sample with 100 times with 100% methanol, filter through 0.22 μ m syringe filter and used for LC-MS analysis.

2.5.3 Instrumentation and Method Validation

Detection of phytosterols was performed on an ultra-performance liquid chromatography (Shimadzu LC-MS/MS 8050) system. The system was operated at a flow rate of 0.3 mL/min without split. The chromatographic separation was carried out on a Fortis C-18 1.7 μ m, 2.1×50 mm analytical column and the temperature maintained at 40°C during the entire experiments. The volume injected into the LC-MS system was 5 μ L. The binary mobile phase consisted of water with methanol (phase A) and acetonitrile (phase B). The isocratic elution condition was 10:90 (Mobile phase A: Mobile phase B). The total chromatographic run time was 8.0 min. The tandem mass spectrometry equipped with an Atmospheric Pressure Chemical Ionization source (APCI) and all three phytosterols were detected in the positive Multiple Reaction Monitoring (MRM) mode. The nebulizer gas, drying gas, heating gas flow rate and collision gas (CID) was set at 2.0, 10.0, 10.0 mL and 270 kPa, respectively. The interface temperature, dissolving line (DL) temperature and heat block temperature were set at 300, 250 and 400°C, respectively. The nitrogen gas was used as nebulizer and collision gas. Optimization of the compounds was performed by injecting individual standard solutions directly into the source (flow injection analysis methods—FIA). The mass parameters of individual compounds were shown in Table 2. The calibration curve for all phytosterols showed 0.99 r^2 value.

Table 2
Mass Spectrometry Parameters Used in the Method Development of Phytosterols Quantification

Compound	Polarity/Scan Mode	Precursor Ion (m/z)	Product Ion (m/z)	Pause time (msec)	Dwell time (msec)	Q1 pre bias (V)	Collision Energy (V)	Q3 pre bias (V)
STIG	Positive	395.3	83.0	3	90	-30	-22	-18
			81.2	3	90	-26	-40	-12
CAM		383.5	146.9	3	90	-21	-23	-25
			81.1	3	90	-21	-23	-25
β -SIT		397.4	147.3	3	90	-16	-22	-20
			161.2	3	90	-6	-21	-18

2.5 Proximate Biochemical Parameters

2.5.1 Moisture content, MC (%)

MC of dried samples was determined by using the oven dry method given by Sadasivam and Manickam, 2005. 5 g samples of each part of all treatments were kept in hot air oven at 105 °C until the constant weight was achieved (approx. 5 hours) and weight was measured.

2.5.2 Chlorophyll content, CC (mg/g)

CC of leaves and stems were analyzed by DMSO method given by Hiscox and Israelstam, 1979. 50 mg of dried powered samples were extracted with 10 mL DMSO and incubated at 65 °C for 3 hours and absorbance was recorded at 645 and 663 nm.

2.5.3 Total carbohydrate content, TCC (%)

TCC was analysed by adopting phenol sulphuric acid method (Sadasivam and Manickam, 2005). 100 mg of sample was taken with 5 mL of 2.5 N HCl and boiled in water bath at 95°C for 3 hours and neutralize with $\text{CH}_2\text{Na}_2\text{O}_4$. Filtered and made up volume of 100 mL with distilled water (DW). Took 0.5 mL aliquot and made the final volume of 1 mL with DW followed by 1 mL phenol and 5 mL H_2SO_4 was added. Incubated for 30 minutes and took the absorbance at 490 nm.

2.5.4 Total protein content, TPC (%)

The kjeldahl method was executed for TPC analysis according to method 981.10 of the AOAC International (Latimer, 2006). 40 mg sample was digested with 1 g of digestion mixture for 40 minutes and solution becomes colorless. Then, 10 mL of 40% NaOH solution was added to each tube and kept for distillation, at the same time 10 mL H_3BO_3 solution with 2–3 drops of MRBC indicator in another 100 mL volumetric flask was taken and it was placed the flask under condenser extending below the surface of the solution for 7 mins. Then H_3BO_3 solution receiving flask was removed and titrated against standard H_2SO_4 solution till first appearance of violet color. For protein estimation used multiplication factor of 6.25.

2.5.5 Reducing sugars, RS (%)

RS was estimated by following the protocol as suggested by Miller (1972). 5 g of sample was extracted with 5 mL of 80% CH_3OH . Supernatant was collected and evaporated on water bath followed by 10 mL of DW was added to dissolve the sugars. Pipette out aliquots of 0.1 or 0.2 mL of CH_3OH free extract and added 1 mL of alkaline copper tartrate. Arseno-molybdic acid reagent (1mL) was added to all the tubes and read the absorbance at 540 nm after 10 mins.

2.5.6 Non-reducing sugar, NRS (%)

It was calculated by subtracting the values of the reducing sugar from total sugars from each sample separately ($\text{NRS} = \text{TSS} - \text{RS}$).

2.4.7 Total soluble sugars, TSS (%)

TSS was determined by phenol sulphuric acid method as described by Dubois *et al.* (1956). 200 mg powder sample was extracted with 10 mL of 80% alcohol. After 24 hours, 1 mL supernatant from each test tube was evaporated to dryness in water bath and makes the volume of 10 mL with DW. From this, 2 mL test solution was used for assay in which freshly prepared 1 mL of 5% phenol solution and 5 mL of conc. H_2SO_4 solution was added and kept for 10 mins. at room temperature. After mixing the solution it was kept for 15 mins. in cold water bath and read the OD at 490 nm.

2.5.8 Fibre content, FC (%)

Acid–base hydrolysis process was adopted for FC analysis (Sadasivam and Manickam, 2005). 200 mL of 1.25% H_2SO_4 mixed with 2 g dried powered samples and boiled for 30 minutes followed by filter through muslin cloth (with 45 thread line). Followed by 200 mL of 1.25% NaOH was added in the residues and boil it again for 30 minutes followed by washed with hot water and 1% HNO_3 . Dry the residues to constant weight at 100°C and ignite it to get ash and record the final weight.

2.5.9 Ash content, AC (%)

The sample was ignited at 600 °C for 6 hrs. using muffle furnace as the method described by Hewageegana et. al. (2014).

2.5.10 Total Flavanoid content, TFC (%)

TFC was estimated by the method as described by Sadasivam and Manickam (2005). Sample (200 mg) was extracted in 80% CH_3OH . 0.5 mL aliquot was taken and made the final volume of 1.0 mL with DW. Added 0.2 mL of 10% AlCl_3 followed by 1 M $\text{CH}_3\text{CO}_2\text{K}$ and made total volume of 10 mL with DW. Kept at room temperature for 10 minutes with intermittent shaking and absorbance was measured at 376 nm.

2.5.11 Tannin content, TC (%)

It was estimated as per the method described by AOAC, 2002. 0.5 g sample was added to 75 mL of DW. The content was refluxed for 2 hours on boiling water bath at 65°C for 30 mins. and made the volume of 100 mL. Aliquot 0.5 mL was taken and made the final volume of 3.0 mL with DW. Followed by 0.5 mL of Folin–Denish reagent was added and after it 1 mL of Na_2CO_3 was added and made final volume of 10 mL with DW. The absorbance was measured at 700 nm.

2.5.12 Antioxidant activity, AOA (%)

The parameter was assay using FRAP method described by Sadasivam and Manickam (2005). 1 g sample were extracted with 10 mL of 60% CH_3OH having 0.1% HCl and was kept on environmental shaker at 150 rpm for 4 hours at room temperature followed by centrifuged at 10 °C of 10000 rpm for 15 mins. The supernatant was used directly for FRAP assay. Aliquots of 1 mL sample were mixed with 3 mL of freshly prepared ferric reducing antioxidant power (FRAP) solution and absorbance was measured at 593 nm after incubated at room temperatue for 10 mins.

2.5.13 Total phenol content, TPHC (%)

It was estimated by the method as described by Sadasivam and Manickam (2005) by using Folin–Ciocalteu reagent (FCR). 200 mg of sample was homogenized with 80% CH_3OH and kept it 1 hr. for shaking followed by centrifuged at 8000 rpm for 10 mins. 0.2 mL of supernatant was mixed with 0.8 mL of

DW and added 1 mL of FCR. After 3 min., 1 mL of 20% of Na₂CO₃ solution was added and the mixture was made up to 5 mL with DW. The absorbance was taken at 620 nm after incubated at room temperature for 30 mins.

2.6 Statistical Analysis

The data collected for different observations are subjected to statistical analysis of variance technique as described by Panse and Sukhatme (1967). The method of "Analysis of Variance" was Factorial CRD and treatment means of all characters studied was further compared by means of critical differences at 5% level of significance employing "F test". Correlation coefficients and principal component analysis were analysed using XLSTAT ver. 2022.3.1 (Addinsoft, USA).

3. Result and Discussion

3.1 Liquid Chromatography-Mass Spectrophotometry (LC-MS) Analysis of Phytosterols content

LC-MS based analysis showed that on concentration of three phytosterols, CAM, STIG and β -SIT of the dried jivanti as influenced by the different drying methods. Results of mean performance analysis indicated that CAM was found significantly differs among the drying methods and its ranges from 1.57 μ g/g (tray drying) to 5.26 μ g/g (shade drying) with SD of 1.33 (Table 3). However, STIG and β -SIT was revealed significantly maximum in vacuum drying (12.05 and 17.90 μ g/g, respectively) while minimum amount was registered in sun drying (STIG: 7.65 μ g/g; β -SIT: 10.84 μ g/g). Substantial losses of phytosterol were observed in various drying methods adopted. Stability of phytosterols is related to their chemical structure, lipid matrix composition, processing temperature and drying duration (Soupas et al., 2004; Rudzinska et al., 2009) which ultimately effects on oxidative reaction of phytosterols (Soupas et al., 2004). Further, it was exposed that chemical structure of phytosterols (Fig. 3) mainly contributed to the degradation level by investigating the stability performance of CAM, STIG, β -SIT at 180 °C (Barriuso et al., 2012). They revealed that CAM was highly vulnerable to deprivation, while STIG and β -SIT was getting less susceptible. It was further confirmed that high phytosterol degradation in rapeseed was related to high drying temperature (Gawrysiak-Witulska et al., 2015). Similarly, on this line in present study relatively minimum amount of CAM was retained with mean value of 2.90 μ g/g as compared to the STIG (mean value, 9.76 μ g/g) and β -SIT (mean value, 13.75 μ g/g).

Table 3
Descriptive Statistics Data of Phytosterols and Proximate Biochemical Parameters of Jivanti Under the Different Drying Method

Drying Method (D)	Phytosterols			Proximate parameters												
	CAM (µg/g)	STIG (µg/g)	β-SIT (µg/g)	MC (%)	CC (mg/g)	TCC (%)	TPC (%)	RS (%)	NRS (%)	TSS (%)	FC (%)	AC (%)	TFC (%)	TC (%)	AOA (%)	TPHC (%)
D1: Sun drying	2.17	7.65	10.84	5.89	18.06	13.99	12.52	3.22	6.06	9.29	35.84	10.28	4.36	3.06	0.67	0.62
D2: Shade drying	5.26	10.34	15.10	6.51	23.26	14.80	13.47	3.10	11.04	14.14	35.91	9.38	4.44	3.02	0.68	0.63
D3: Vacuum drying	4.57	12.05	17.90	6.06	22.51	14.45	12.43	4.55	6.09	10.30	44.61	16.23	5.92	2.92	0.71	0.83
D4: Oven drying	2.76	9.53	13.38	6.39	19.36	14.40	12.45	3.10	8.44	11.54	39.66	10.15	4.15	2.98	0.65	0.57
D5: Tray drying	1.57	9.70	11.31	5.82	20.19	14.00	12.66	3.32	4.93	8.26	36.82	9.67	4.04	3.49	0.65	0.54
D6: Microwave continuous drying	1.72	8.61	12.23	6.47	20.15	14.00	12.47	3.31	3.85	7.15	38.42	11.36	4.02	2.91	0.61	0.52
D7: Microwave vacuum drying	2.45	9.73	14.51	6.10	20.74	14.15	12.50	3.57	5.35	8.94	40.29	12.62	4.21	3.05	0.66	0.59
D8: Fluidized bed drying	2.72	10.44	14.72	6.96	20.72	13.99	12.48	3.51	5.86	9.37	36.23	8.31	4.31	2.95	0.66	0.59
Min.	1.57	7.65	10.84	5.82	18.06	13.99	12.43	3.10	3.85	7.15	35.84	8.31	4.02	2.91	0.61	0.52
Max.	5.26	12.05	17.90	6.96	23.26	14.80	13.47	4.55	11.04	14.14	44.61	16.23	5.92	3.49	0.71	0.83
Mean	2.90	9.76	13.75	6.28	20.62	14.22	12.62	3.46	6.45	9.87	38.47	11.00	4.43	3.05	0.66	0.61
SD	1.33	1.30	2.31	0.38	1.65	0.30	0.35	0.47	2.27	2.16	3.02	2.48	0.62	0.19	0.03	0.10
S.Em. ±	0.05	0.16	0.21	0.06	0.29	0.18	0.21	0.09	0.11	0.21	0.88	0.18	0.07	0.03	0.01	0.01
C.D. %	0.14	0.46	0.60	0.17	0.82	NS	NS	0.24	0.31	0.59	2.50	0.52	0.19	0.09	0.03	0.04
C.V. %	5.00	4.95	4.58	2.83	4.20	3.97	4.93	7.36	5.13	6.39	6.84	4.95	4.61	2.98	5.40	6.00
#NS: Non-significant, CAM: Campesterol, STIG: Stigmasterol, β-SIT: β-Sitosterol, MC: Moisture content, CC: Chlorophyll content, TCC: Total carbohydrate content, PC: Total protein content, RS: Reducing sugar, NRS: Non-reducing sugar, TSS: Total soluble sugars, FC: Fibre content, AC: Ash content, TFC: Total flavonoid content, TC: Tannin content, AOA: Anti-oxidant activity, TPHC: Total phenol content, SD: Standard deviation																

3.2 Mean Performance of Proximate Biochemical Parameters of Jivanti Under the Influenced of Different Drying Method

Descriptive statistical analysis of proximate biochemical parameters data is presented in Table 3 and its analysis of variance (ANOVA) at significant difference ($p < 0.05$) is exposed in supplementary Table S2. Mean performance analysis showed that differences among the drying methods in all the parameters except TCC and TPC were significant. The results suggested that the entire drying methods implemented in present experiment the MC reduced below 7.0%. The outcome of mean performance exposed that MC with a mean value of 6.28% among the drying methods ranged from 5.82% (tray drying) to 6.96% (fluidized bed drying). It showed that the supremacy of moisture reducing potential over the conventional drying methods in a short period of drying time (Table 1). Moisture ranged found in present studies is safe in terms of shelf life and storability as prescribed in the European Pharmacopoeia, 2005 and Raaman, 2006. The maximum CC (23.26 mg/g) was registered in shade drying which was at par with vacuum drying (22.51 mg/g) and while the minimum was recoded in sun drying (18.06 mg/g). This finding was in harmony with works done in savoy beet & amaranath leaves (Negi and Roy, 2001) and green tea leaves (Roshanak *et al.*, 2016). The chlorophyll pigments are sensitive to heat, disassembly and degradation of chlorophyll-containing protein complexes was take place *in vivo* (Lipora *et al.*, 2010). Disruption of PS-II was shown at the temperature of 42–48 °C (Cramer *et al.*, 1981) and thylakoid membrane disruption at 60 °C (Smith and Low, 1989) which results probably in denaturation of PS-II reaction centre.

However, RS was ranged from 3.10% (shade drying) to 4.55% (vacuum drying) with the mean value of 3.46 in present study. Vyankatrao, 2014 found that curry leaves dried under shade showed minimum RS (3.02%) followed by oven drying (3.20% at 60 °C) and maximum was in sun drying (3.55%). But, it was contrast with the finding in sapota powder that RS was less in solar dryer as compared to oven drying (Bala *et al.*, 2017). Although in present study NRS (11.04%) and TSS (14.14%) was registered significantly maximum in shade drying followed by oven drying while minimum was recorded in microwave continuous drying (3.85% NRS; 7.15% TSS). Ding *et al.*, 2017 revealed that sucrose (NRS) did not change in air dried lemon slices at the temperature of 50 to 60°C and little alterations in fructose or glucose content (RS) up to a temperature of 70°C. But, it was mentioned that under the higher temperature sucrose

hydrolyzed to fructose and glucose *via* acid catalysis. At present studies NRS was started degradation beyond the temperature of 30°C. It explains the loss of NRS during high temperature applied in all drying treatments except shade drying.

Jivanti crop showed very fibrous in nature, it was ranged from 35.84% (sun drying) to 44.61% (vacuum drying) with the mean value of 38.87%. Fibre represents the undigested complex of carbohydrate and lignin and its consumption at adequate amount is linked to the prevention of various diseases. Dietary fibre content in dried pumpkin, red cabbage and guava showed higher in sun drying method as compared to hot air oven and freeze drying, but the result was contrast in yardlong bean and tomato where significantly higher dietary fibre was revealed under the hot air oven followed by freeze drying (Siriwattananon and Maneerate, 2016).

Significantly maximum amount of AC (16.23%), TFC (5.92), AOA (0.71%) and TPHC (0.83%) with considerably less amount of TC (2.92%) was registered in vacuum drying in present study in jivanti crop as compared to other drying methods. Our results were analogous to the consequences of a previous study, which found that vacuum drying applied on coffee pulp (Kieu Tran et al., 2020) and *Paramignya trimera* root (Nguyen et al., 2016), had higher TFC, AOA (ATBS and FRAP method) and TPC than hot air drying. Furthermore, in *Ocimum tenuiflorum* were also reported that vacuum dried samples had the highest TPHC (Rabeta and Lai 2013). Tannin is water soluble polyphenol is generally considered as anti-nutritional factor (Samtiya et al., 2020) and in jivanti crop its ranges from 2.91 to 3.49% with the mean value of 3.05% as influenced by different drying methods.

3.3 Mean Performance of Proximate Biochemical Parameters and Phytosterols Content in Jivanti Leaf, Stem and Root Subject to the Different Drying Method

The statistical data of mean performance of various proximate biochemical parameters and three phytosterols content in dried jivanti leaf, stem and root with respect to the different drying methods are shown in Table 4. Results showed that leaves (P1) used as drying part retained maximum amount of STIG (28.34 µg/g) and β-SIT (44.51 µg/g) in vacuum drying followed by shade drying (STIG: 27.57 µg/g; β-SIT: 41.66 µg/g). However, CAM was also revealed maximum retention in P1 with the mean value of 7.85% as compared to the P2 (0.58%) and P3 (0.27) but there was great variation among the same plant part (P1) dried under the different drying methods *i.e.*, maximum in D2 (14.92 µg/g) and minimum in D5 (4.33 µg/g). The minimum amount of MC with the value of 5.95% was observed in stem (P2) as compared to the leaf (P1, 6.28%) and root (P3, 6.59%). While maximum CC was registered in all the drying methods used P1 as drying plant part (D1: 40.03, D2: 57.97, D3: 50.49, D4: 47.88, D5: 45.94, D6: 45.78, D7: 50.87 and D8; 45.71 mg/ g) with the mean value of 18.03 mg/ g. Similarly, TCC (15.47%) and TPC (20.15%) and RS (3.69%) was obtained significantly maximum in P1. There was great variation in FC among the plant parts and found significantly maximum FC (53.23%) under the P3. Root dried under the vacuum drying showed the maximum FC (59.27%) as compared to the other drying methods. Results showed that P1 used as drying part retained maximum amount of TFC (7.69%) and AOA (0.75%) dried in vacuum drying. In case of TPFC, P3 dried under the vacuum drying registered significantly maximum (0.90%) content which was at par with the P1 (0.85%) dried under the same drying method.

Table 4
Expression of Phytosterols and Proximate Parameters in Different Plant Parts of Jivanti Under the Influence of Various Drying Method

Drying Method (D)	Plant part (H)	CAM (µg/g)	STIG (µg/g)	β-SIT (µg/g)	MC (%)	CC (mg/g)	TCC (%)	TPC (%)	RS (%)	NRS (%)	TSS (%)	FC (%)	AC (%)	TFC (%)	TC (%)	AOA (%)	TPHC (%)
D1	P1	5.80	16.57	28.90	5.50	40.03	16.24	18.35	3.58	7.18	10.77	12.82	16.55	6.05	3.29	0.72	0.01
	P2	0.43	5.81	3.34	5.10	14.16	14.26	12.79	3.34	5.36	8.71	46.35	10.39	4.40	3.11	0.63	0.01
	P3	0.28	0.57	0.28	7.07	0.00	11.50	6.43	2.74	5.65	8.39	48.36	3.89	2.62	2.79	0.66	0.01
D2	P1	14.92	27.57	41.66	7.17	57.97	17.57	17.73	2.47	9.63	12.10	14.28	17.25	5.86	3.42	0.75	0.01
	P2	0.55	2.79	3.31	5.07	11.83	16.46	15.16	3.74	14.57	18.31	43.32	6.23	4.29	2.97	0.63	0.01
	P3	0.33	0.67	0.33	7.30	0.00	9.75	7.51	3.09	8.91	12.00	50.13	4.65	3.16	2.69	0.65	0.01
D3	P1	11.36	28.34	44.51	5.90	50.49	13.11	21.68	5.13	2.33	7.45	22.15	30.39	7.69	2.77	0.75	0.01
	P2	2.10	7.32	8.93	6.23	17.04	17.80	9.89	4.35	7.38	11.73	52.40	15.47	4.80	2.92	0.67	0.01
	P3	0.24	0.50	0.26	6.03	0.00	12.45	5.72	3.16	8.56	11.73	59.27	2.84	5.29	3.24	0.70	0.01
D4	P1	7.41	23.33	36.72	6.53	47.88	16.80	20.14	2.72	8.25	10.97	10.46	17.02	5.87	3.31	0.61	0.01
	P2	0.60	4.78	3.20	5.37	10.21	17.09	10.86	3.60	10.08	13.67	49.26	10.29	3.92	2.88	0.70	0.01
	P3	0.27	0.47	0.23	7.27	0.00	10.49	6.35	2.98	7.00	9.98	59.26	3.15	2.69	2.66	0.63	0.01
D5	P1	4.33	15.25	31.76	6.30	45.94	14.20	21.78	3.54	4.85	8.40	11.40	17.58	5.14	3.78	0.64	0.01
	P2	0.10	13.18	1.90	6.17	14.63	14.07	10.25	3.85	5.81	9.67	47.77	7.44	4.17	3.35	0.67	0.01
	P3	0.27	0.66	0.27	5.00	0.00	13.72	5.95	2.57	4.13	6.70	51.29	4.00	2.82	3.34	0.65	0.01
D6	P1	4.53	19.09	33.67	6.23	45.78	15.28	19.60	3.73	3.04	6.75	14.87	22.24	4.28	3.22	0.62	0.01
	P2	0.33	6.09	2.71	7.13	14.67	14.22	10.95	3.30	2.35	5.65	49.14	6.27	4.41	2.71	0.62	0.01
	P3	0.29	0.65	0.30	6.03	0.00	12.50	6.86	2.88	6.16	9.04	51.26	5.58	3.36	2.80	0.59	0.01
D7	P1	6.67	20.62	40.75	5.10	50.87	13.65	21.44	4.48	6.59	11.07	13.77	24.01	6.25	3.28	0.68	0.01
	P2	0.43	7.93	2.54	7.10	11.33	15.89	9.65	3.16	6.14	9.32	50.87	11.07	3.41	3.02	0.62	0.01
	P3	0.24	0.63	0.25	6.10	0.00	12.89	6.41	3.08	3.34	6.42	56.26	2.78	2.99	2.88	0.68	0.01
D8	P1	7.76	21.36	41.76	7.47	45.71	16.87	20.51	3.84	7.39	11.23	11.65	19.04	4.26	3.09	0.65	0.01
	P2	0.12	9.39	2.12	5.47	16.45	12.03	11.44	3.45	5.72	9.19	47.02	3.00	2.80	2.95	0.63	0.01
	P3	0.27	0.56	0.27	7.95	0.00	13.09	5.49	3.24	4.46	7.70	50.01	2.88	5.87	2.73	0.70	0.01
S.Em.±		0.08	0.38	0.36	0.10	0.50	0.33	0.21	0.02	0.19	0.36	1.52	0.32	0.12	0.05	0.02	0.01
C. D. %		0.24	0.79	1.03	0.17	1.42	0.93	0.59	0.41	0.54	1.03	4.33	0.89	0.34	0.15	0.06	0.01
C. V. %		5.00	4.95	4.58	2.83	4.20	3.97	4.93	7.36	5.13	6.39	6.84	4.95	4.61	2.98	5.40	6.01
Leaves (P1)		7.85	21.52	37.47	6.28	18.03	15.47	20.15	3.69	6.16	9.84	13.92	20.51	5.68	3.27	0.68	0.01
Stems (P2)		0.58	7.16	3.51	5.95	5.17	15.23	11.37	3.60	7.18	10.78	48.27	8.77	4.02	2.99	0.64	0.01
Roots (P3)		0.27	0.59	0.27	6.59	0.00	12.05	6.34	2.97	6.03	8.99	53.23	3.72	3.60	2.89	0.66	0.01
S.Em.±		0.03	0.10	0.13	0.04	0.18	0.12	0.1	0.05	0.07	0.13	0.54	0.11	0.04	0.02	0.007	0.01
C. D. %		0.08	0.28	0.37	0.10	0.50	0.33	0.36	0.15	0.19	0.36	1.52	0.32	0.12	0.05	0.021	0.01

MC: Moisture content, CC: Chlorophyll content, TCC: Total carbohydrate content, PC: Total protein content, RS: Reducing sugar, NRS: Non-reducing sugar, TSS: Total soluble sugars, FC: Fibre content, AC: Ash content, TFC: Total flavonoid content, TC: Tannin content, AOA: Anti-oxidant activity, TPHC: Total phenol content
CAM: Campesterol, STIG: Stigmasterol, β-SIT: β-Sitosterol

Most predominant form of phytosterols existing in plants is sitosterol than any other phytosterol, and it is usually occurred in higher concentration (Pollak 1985). Similarly, maximum amount of phytosterol was β-SIT (37.47 µg/g) followed by STIG (21.52 µg/g) and CAM (7.85 µg/g) in dried leaves of jivanti while in stem and root maximum retention was STIG, 7.16 and 0.59 µg/g respectively in present study. It had also been reported earlier that an irregularity in the concentrations of the phytochemicals in the different plant part (Jamaludin et al., 2011) which could be due to the variation in the accumulation of secondary metabolites of the various plant parts (Lahlou, 2004). In the same line most abundant phytosterols identified in *S. crispus* were β-SIT and STIG, both of which were reported to have an antioxidant effect (Yoshida and Niki, 2003) and maximum sitosterol was also reported in fig pith (86.2) in terms of percent composition than bark, stem and fruit (Jeong and Lachance, 2001). It signified the accumulation of secondary metabolites differs among the plant parts (Bartwal et al., 2013) as well as their retention differs based on the drying techniques.

Further, Bernard et al., 2014 showed that leaf retained maximum amount of flavonoid (24.28 mg GAE/g) followed by seed, root and stem in cinnamon dried in different drying techniques while maximum phenolic content was in root (0.22 mg GAE/g). Plant cell integrity is loose under the thermal treatment during the drying period due to the modification in plant cell microstructure (Gonzalez *et al.*, 2010) which ultimately make in an easy release of cell constituents from plant cells (Yahia, 2009). The finding was in agreement with past record that dried leaves of *Ocimum* sp., it had been showed that maximum tendency of increased bioactivity in dried product (Rabeta and Lai, 2013). Furthermore, total antioxidant activity in plants is derived from the presence of phenolic compounds and terpene derivatives are widely accepted. Therefore, leaf contributed significantly maximum amount of AOA (0.68%) with higher concentration of TFC (5.68%) and TPHC (0.71%) in present study.

3.4 Inter Trait Correlation (R²)

Table 5 showed Pearson correlation analysis among the proximate biochemical parameters and phytosterols content of jivanti dried under the different drying methods. The understanding of correlation helps in identification of less significant traits with low priority, ultimately which will help to increase the value of products with respect to the right choose of drying techniques. Results showed that TCC of dried jivanti was significantly positively R² with CC (P < 0.05). It indicated that large amount of carbohydrates was accumulated or synthesized through the process of photosynthesis. Further it was showed that significantly positively R² of NRS with TCC (P < 0.01) and TPC (P < 0.05). A similar pattern of relationship was observed between TFC with RS, FC and AC while AOA was significantly positively R² with TFC (P < 0.05). Higher antioxidant activity of the dried product is due to the presence of more total phenol, in fact flavonoid is also types of phenol. Earlier it had been reported that more phenolic compounds released upon the drying due to the cellular constituents' breakdown (Chang et al. 2006; Arslan and Ozcan 2010). In present studies AOA was significantly positively R² with CAM (P < 0.05) but STIG and β-SIT were not significantly contributed to the AOA. Phytosterols represent group of plant sterols which is chemically acts as an antioxidant, a modest radical scavenger (Yoshida and Niki, 2003).

Table 5
Pearson Correlation Coefficient among the Proximate Biochemical Parameters and Phytosterols Present in Different Plant Parts of Jivanti Dried Under the V Method

	MC	CC	TCC	TPC	RS	NRS	TSS	FC	AC	TFC	TC	AOA	TPHC	CAM	STI
MC	1	0.28 ^{NS}	0.14 ^{NS}	0.15 ^{NS}	-0.17 ^{NS}	0.25 ^{NS}	0.24 ^{NS}	-0.24 ^{NS}	-0.42 ^{NS}	-0.16 ^{NS}	-0.58 ^{NS}	-0.22 ^{NS}	-0.18 ^{NS}	0.23 ^{NS}	0.21
CC		1	0.72 [*]	0.59 ^{NS}	0.43 ^{NS}	0.44 ^{NS}	0.53 ^{NS}	0.31 ^{NS}	0.31 ^{NS}	0.52 ^{NS}	-0.18 ^{NS}	0.49 ^{NS}	0.51 ^{NS}	0.81 [*]	0.8
TCC			1	0.69 ^{NS}	0.08 ^{NS}	0.87 ^{**}	0.91 ^{**}	0.24 ^{NS}	0.19 ^{NS}	0.41 ^{NS}	-0.27 ^{NS}	0.54 ^{NS}	0.47 ^{NS}	0.91 ^{**}	0.5
TPC				1	-0.37 ^{NS}	0.76 [*]	0.73 [*]	-0.44 ^{NS}	-0.34 ^{NS}	-0.09 ^{NS}	0.14 ^{NS}	0.22 ^{NS}	-0.01 ^{NS}	0.61 ^{NS}	0.1
RS					1	-0.30 ^{NS}	-0.14 ^{NS}	0.82 [*]	0.85 ^{**}	0.89 ^{**}	-0.23 ^{NS}	0.61 ^{NS}	0.84 ^{**}	0.34 ^{NS}	0.7
NRS						1	0.99 ^{**}	-0.18 ^{NS}	-0.25 ^{NS}	0.10 ^{NS}	-0.16 ^{NS}	0.43 ^{NS}	0.20 ^{NS}	0.76 [*]	0.2
TSS							1	-0.06 ^{NS}	-0.13 ^{NS}	0.24 ^{NS}	-0.21 ^{NS}	0.55 ^{NS}	0.34 ^{NS}	0.84 ^{**}	0.3
FC								1	0.92 ^{**}	0.73 [*]	-0.34 ^{NS}	0.39 ^{NS}	0.67 ^{NS}	0.28 ^{NS}	0.6
AC									1	0.78 [*]	-0.29 ^{NS}	0.46 ^{NS}	0.74 [*]	0.29 ^{NS}	0.4
TFC										1	-0.34 ^{NS}	0.82 [*]	0.99 ^{**}	0.65 ^{NS}	0.7
TC											1	-0.10 ^{NS}	-0.34 ^{NS}	-0.40 ^{NS}	-0.1
AOA												1	0.89 ^{**}	0.75 [*]	0.6
TPHC													1	0.72 ^{NS}	0.6
CAM														1	0.7
STIG															1
β-SIT															

MC: Moisture content, CC: Chlorophyll content, TCC: Total carbohydrate content, PC: Total protein content, RS: Reducing sugar, NRS: Non-reducing sugar, TS soluble sugars, FC: Fibre content, AC: Ash content, TFC: Total flavonoid content, TC: Tannin content, AOA: Anti-oxidant activity, TPHC: Total phenol content, CAP: Campesterol, STIG: Stigmasterol, β-SIT: β-Sitosterol, *, **: Significant at 5% and 1% respectively, R²: Correlation

3.5 Principal Component Analysis (PCA)

PCA is a multivariate practice that evaluates a data table in which observations are designated by several inter-correlated measureable dependent variables. It simplifies the complexity in high-dimensional data and extracts the information from the statistical data and convert into a set of new uncorrelated variables called principal components (Sidharth et al., 2017). The principal component analysis revealed that the first three components defined a cumulative variability of 87.02% (Table 6, Fig. 3). The Eigen values for the first three components were more than 1 which extensively indicated the variation in biochemical parameters and phytosterols content in dried jivanti. Out of 20 variables, only one variable (TC) was negatively associated with PC1 in present study and MC

(0.025) and TC (-0.142) variable disclosed least contribution to PC1 variability. The maximum contribution of variability in PC2 was due to TPC, RS, NRS, TSS, FC and AC and PC2 had a positive association with MC, CC, TCC, TPC, NRS, TSS, TC and CAM. The variables like β -SIT (10.97%), CAM (10.22%), TPHC (10.09%), TFC (9.71%) and STIG (9.07%) are significant variables in charge for creating variability in jivanti drying while considering PC1. However, maximum variability in jivanti drying was due to TPC (16.84%), NRS (15.92%), TSS (13.00%) and AC (10.69%) in PC2. PCA also demonstrated that among the eight drying methods used in jivanti drying techniques, vacuum drying (D3) contributed 56.26% variation followed by shade drying, D2 (12.26%) of total variation (Table 6). The maximum contributing variable which comprises RS, FC, AC, TFC, AOA, TPHC, STIG and β -SIT were shared by vacuum drying (D3) (Supplementary Fig. 4, 5). In case of shade drying (D2) MC, CC, TCC, TPC, NRS, TSS and CAM contributed to major variation.

Table 6
PCA Analysis of Phytosterols and Proximate Biochemical Content in Dry Jivanti

Trait	Principal Components			Contribution of variables (%)		
	PC1	PC2	PC3	PC1	PC2	PC3
CAM	0.320	0.201	-0.001	10.222	4.057	0.000
STIG	0.301	-0.044	0.079	9.071	0.194	0.629
β -SIT	0.331	-0.039	0.220	10.971	0.152	4.820
MC	0.025	0.199	0.669	0.060	3.977	44.816
CC	0.281	0.134	0.065	7.914	1.786	0.416
TCC	0.267	0.272	-0.074	7.105	7.417	0.542
TPC	0.094	0.410	-0.193	0.875	16.843	3.706
RS	0.249	-0.330	0.017	6.196	10.871	0.028
NRS	0.164	0.399	-0.083	2.693	15.919	0.693
TSS	0.211	0.360	-0.082	4.433	12.996	0.668
FC	0.226	-0.308	0.048	5.121	9.461	0.234
AC	0.221	-0.327	-0.083	4.889	10.686	0.688
TFC	0.312	-0.187	-0.072	9.708	3.497	0.520
TC	-0.142	0.014	-0.576	2.006	0.019	33.228
AOA	0.294	-0.009	-0.276	8.647	0.008	7.641
TPHC	0.318	-0.146	-0.117	10.090	2.118	1.371
Eigenvalue	7.903	4.324	1.697			
Variability (%)	49.391	27.023	10.609			
Cumulative %	49.391	76.414	87.023			
Drying method (D)	Contribution of drying method (%)					
D1	8.549	0.431	11.832			
D2	12.262	63.367	1.210			
D3	56.179	24.996	0.680			
D4	0.364	2.830	1.742			
D5	10.787	0.597	33.975			
D6	11.421	3.394	19.193			
D7	0.028	3.994	0.011			
D8	0.410	0.393	31.356			
#CAM: Campesterol, STIG: Stigmasterol, β -SIT: β -Sitosterol, MC: Moisture content, CC: Chlorophyll content, TCC: Total carbohydrate content, PC: Total protein content, RS: Reducing sugar, NRS: Non-reducing sugar, TSS: Total soluble sugars, FC: Fibre content, AC: Ash content, TFC: Total flavonoid content, TC: Tannin content, AOA: Anti-oxidant activity, TPHC: Total phenol content, D1: Sun drying, D2: Shade drying, D3: Vacuum drying, D4: Oven drying, D5: Tray drying, D6: Microwave continuous drying, D7: Microwave vacuum drying, D8: Fluidized bed drying						

4. Conclusion

From the above results, it can be concluded that the vacuum drying method showed the potential to produced dried form of jivanti with considerably higher phytosterols (STIG and β -SIT) and proximate biochemical parameters (RS, FC, AC, TFC, AOA and TPHC) retention under short duration of drying period. Moreover, the shade drying samples exhibited the maximum preservation of CC, TCC, TPC, TSS, NRS and CAM; however, shade drying methods experienced

long time to dry the samples. Among the different plant parts of jivanti, leaf disclosed maximum amount of phytosterols and its proximate phytochemicals value as compared to stem and root. The maximum content of β -SIT (37.47 $\mu\text{g/g}$), STIG (21.52 $\mu\text{g/g}$) and CAM (7.85 $\mu\text{g/g}$) was obtained in dried jivanti leaves. AOA of dried jivanti was significantly positively correlated with TPHC and CAM and positive correlation with STIG and β -SIT was confirmed.

Declarations

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Figures

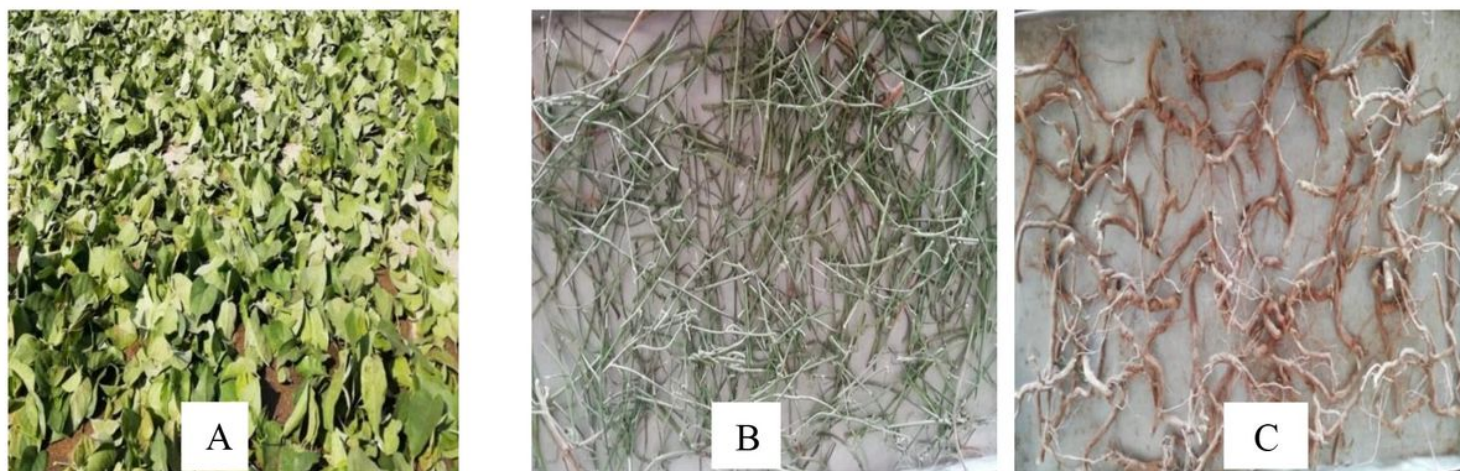


Figure 1

Different plant parts of jivanti used in drying, A: Leaf B: Stem C: Root

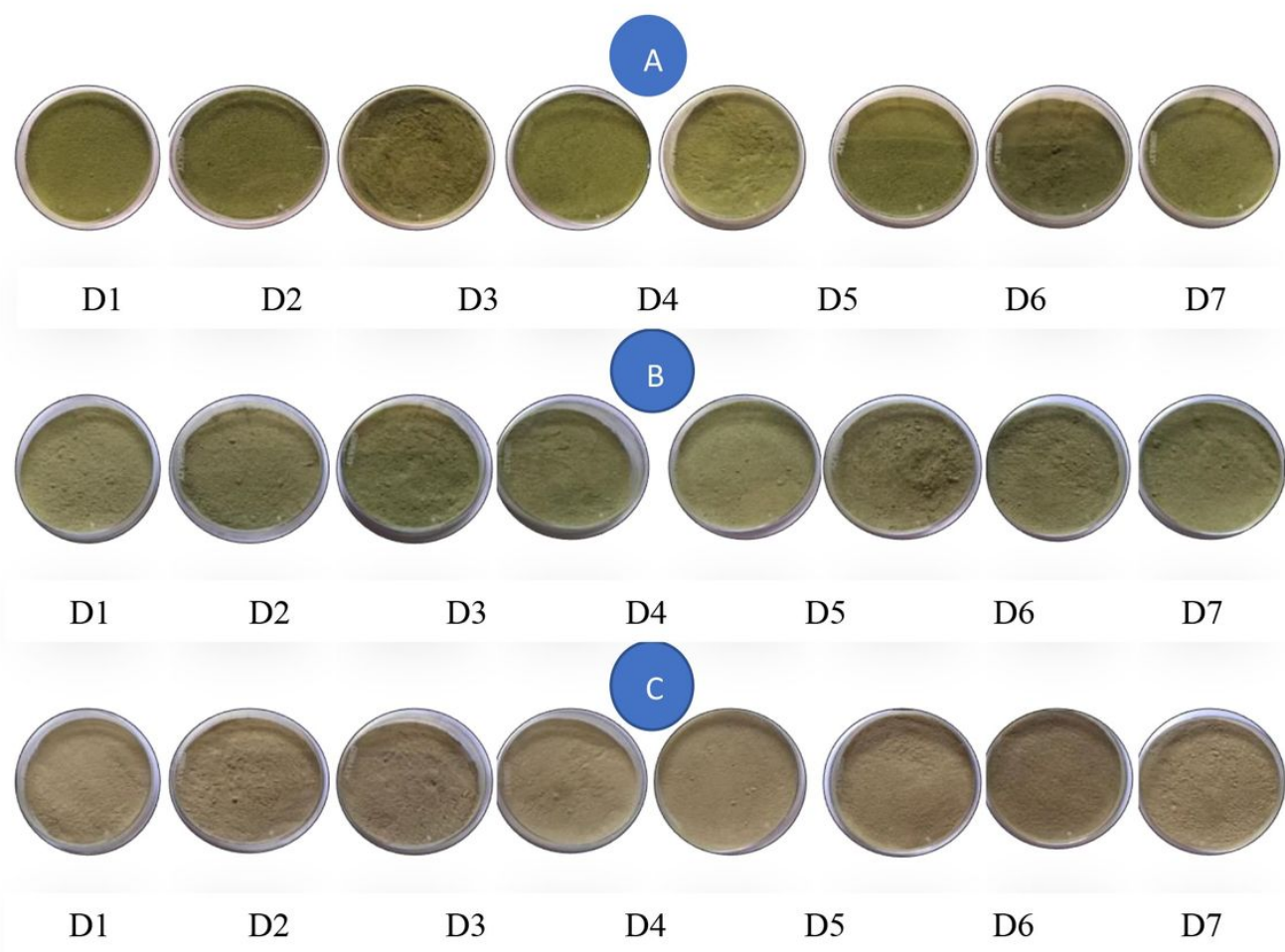


Figure 2

Physical appearance of dried powder, A: Leaf B: Stem C: Root

D1: Sun drying, D2: Shade drying, D3: Vacuum drying, D4: Oven drying, D5: Tray drying, D6: Microwave continuous drying, D7: Microwave vacuum drying, D8: Fluidized bed drying

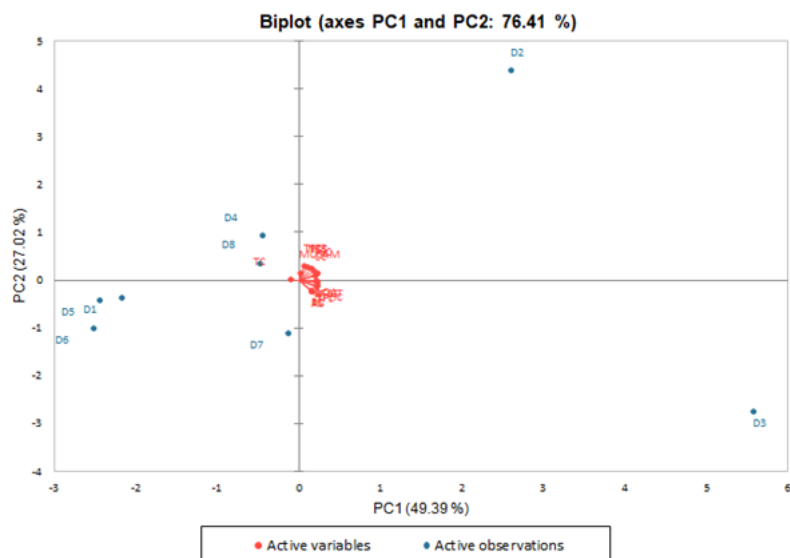


Figure 3

PCA analysis of biochemical parameters and phytosterols contents of dry jivanti using different drying methods [(Active observation: Drying methods which included D1: Sun drying, D2: Shade drying, D3: Vacuum drying, D4: Oven drying, D5: Tray drying, D6: Microwave continuous drying, D7: Microwave vacuum drying, D8: Fluidized bed drying) (Active variables: Biochemical parameters and phytosterols)]

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