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Study on properties of ash gourd aqueous extracts trapped using solar based innovative vacuum drying system compared with hydrodistillation aqueous extract

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Abstract
Ash gourd (*Benincasa hispida*) is a vegetable belonging to the cucurbits family. It is commonly used in preparation of traditional foods and also as a therapeutic ingredient due to the presence of beneficial phytochemicals. Distillation extracts contain various aroma compounds which can be utilized effectively in various products. The maximum temperature reached in innovative drying system was 55 ºC and evaporated vapours were trapped and analysed. Aqueous extracts collected have been analysed for various physicochemical and bioactive properties. The L* value representing lightness/darkness was 2.46 and 3.48, a*(redness/greenness) -0.12 and 0.07, b* (yellowness/blueness) -0.59 and -0.34 for hydrodistillation ash gourd extract (HDAG) and Vacuum Dryer ash gourd extract (VDAG) respectively. Negative a* and b* values indicate that extracts have a slight greenish and bluish colour shade. The pH readings of extracts were near to neutral that is 6.61 for extract collected from dryer and 7.61 hydrodistillation extract. It was found that both extracts were having very low total soluble solids and refractive index was same that is 0.1% Brix. The Phenolic content of distillation extract is higher than that of dryer extract. Flavonoid content is 4.1 and 4.94 Quercetin Equivalent mg/100 mL in the extracts. Antioxidant scavenging activity was measured by percent DPPH inhibition.

Keywords: Ash gourd, Innovative drying system, aqueous extracts, physicochemical, bioactive

1. Introduction
Ash gourd (*Benincasa hispida*) is a vegetable belonging to cucurbits family. It is a commonly used vegetable and also a therapeutic ingredient due to the presence of beneficial phytochemicals (Gupta *et al*., 2021) [10]. It is used for preparation of various spicy and sweet traditional cuisines providing benefits to health (Bhutkar *et al*., 2015) [3]. Distillation extracts of ash gourd contains various aroma compounds which can be utilized effectively in various products (J. Sharma *et al*., 2010) [20].

Drying has effects on overall properties of raw material due to loss of moisture. The flavour and some sensitive bioactive compounds also get lost along with the moisture. Various drying techniques have been developed and studied for their effect on nutritional, bioactive and physical properties (Feng *et al*., 2021) [8]. Solar drying is used for a long time and it is a cost-efficient method with a simple design based on conventional energy (A. Sharma *et al*., 2009) [19]. The water vapours evaporated from raw material due to heat generated by solar energy can be trapped using a vacuum. The vacuum is generating void space by reducing pressure and helps in various operations like filtration, cooling, mixing and also drying of materials. Drying using vacuum generated by vacuum pump assists in the removal of moisture from raw material and trapping (Hari Sairam & Rao PVK, 2021) [12].

The hydrodistillation process generates aqueous extracts after separation of essential oil in form of hydrosols and possesses medicinal and bioactive properties (Sutour *et al*., 2020). In this study, the water vapours evaporated from an innovative drying system were trapped and compared with distillation hydrolats. These extracts can be utilized in product development, cosmetics and many other industries.

2. Materials and Methods
2.1 Materials
Ash gourd was procured from regional market of Thanjavur, Tamil Nadu. It is washed under tap water to remove settled soil particles. After primary processing (peel removal, cutting),

these were placed on a tray of solar based innovative drying system designed and developed at National Institute of Food Technology, Entrepreneurship and Management (NIFTEM) - Thanjavur. The chemicals required for analysis were purchased from SRL chemicals, Pvt. Ltd. through institute registered vendors.

2.2 Extracts collection from solar based innovative drying system

The water vapours were condensed, trapped and collected with the help of a condenser and assisted vacuum pump and were stored in ambered coloured glass bottles in refrigerated condition (Harini *et al*., 2019) [13]. The collected sample being aqueous extracts, Vacuum Dryer ash gourd extract (VDAG) were analysed for various physicochemical and bioactive properties. The maximum temperature reached in the system was 55 ºC.

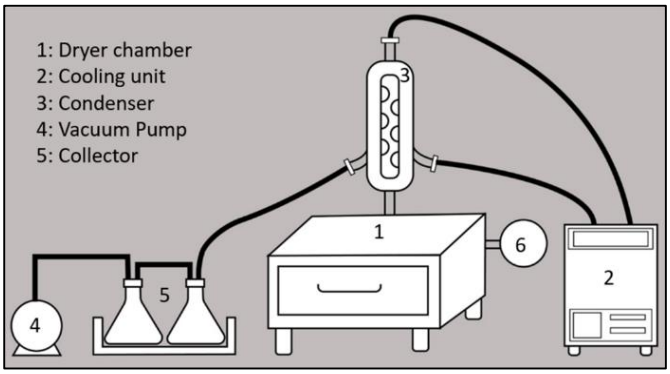

Fig 1: Design of solar based innovative vacuum drying system

2.3 Hydrolat extraction for comparison with dryer extract

Hydrolat is the aqueous extract obtained by hydrodistillation of material after separating essential oil layer (Drinić *et al*., 2020) [7]. This was extracted for comparing with the extract collected from dryer.

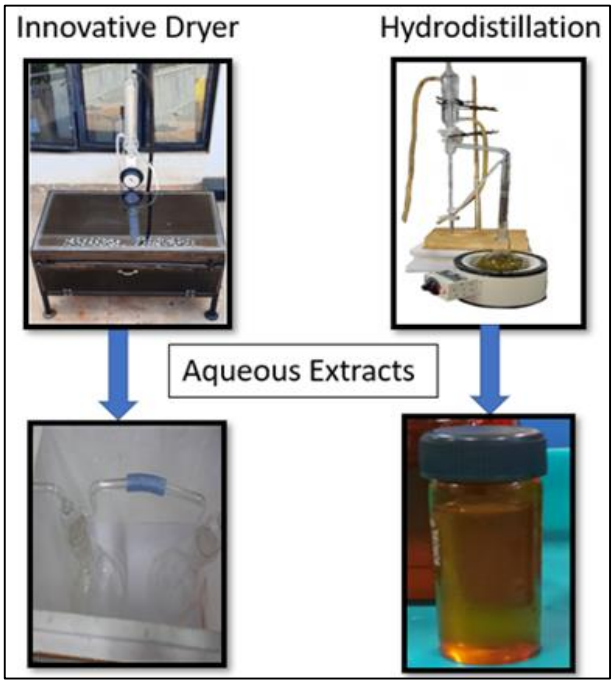

Fig 2: Illustration of aqueous extract collection from innovative dryer system and hydrodistillation apparatus

2.4 Physicochemical analysis of aqueous extract collected from dryer and hydrodistillation

2.4.1 Colour

The Hunter Lab colourimeter was used for determination of colour values of volatiles (Hunter Association Laboratory, Inc., USA). Samples were poured into sample cup and then cup was placed on the instrument port. The colour values L* (lightness), a* ((+)-redness, (-)-greenness) and b* ((+)-yellowness, (-)-blueness) were displayed on screen (Jha *et al*., 2018) [15].

2.4.2 pH

pH is a measure of potential hydrogen ion concentration in the sample. The digital pH meter (Eutech Instruments Pvt. Ltd., Singapore) with probe was used to measure pH. The probe was placed in sample and reading was displayed on screen (Chen *et al*., 2018) [4].

2.4.3 Total Soluble Solids

Total soluble solids were determined using digital refractometer (Milwaukee, Romania - MA871) ranging between 0 to 85% brix. Extract drops were added on the prism of the refractometer and 'Read' button was pressed to obtain reading (Gimhani & Liyanage, 2019) [19].

2.4.4 Specific gravity

Pycnometer of total capacity of 10 ml was used to obtain specific gravity value of ash gourd and mint volatiles collected using system. It is unitless term that measure density of volatiles relative to that of water (Oyebadejo *et al*., 2019) [18].

2.5. Bioactive properties

2.5.1 Total phenolic content

The commonly used method for phenolic content calculation (Folin Ciocalteu reagent method) was employed. It is UV spectrophotometric method (UV Spectrophotometer-Shimadzu Corporation, Japan- UV 1800) method in which absorbance readings after specific incubation time are used to determine phenolic content (Hasperué *et al*., 2016) [4]. Sample volume was taken as 1 ml and added to test tube covered with aluminium foil to avoid light degradation. After adding sample, 500µl Folin Ciocalteu reagent (1:10) and 1000µl sodium carbonate (7.5%) were added. Covered test tubes were kept in dark at room temperature for incubation period of one hour and then absorbance readings were noted. The total phenolic content was obtained by comparing absorbance readings taken at 750 nm of sample with different concentrations of standards prepared along with other reagents (Amaral *et al*., 2018) [1].

2.5.2 Total flavonoid content

Similar to phenolic content, flavonoid content was also calculated using spectrophotometric method. Aluminium chloride (2%) was used as reagent and quercetin as standard for this analysis. Quercetin stock solution was prepared as 0.1 g in 100 ml and further working standard as 10 ml of stock solution in 90ml distilled water. This working standard was used to prepare different concentrations of quercetin standards along with reagents to generate standard curve. The 500µl sample and prepared reagent were added in test tube and after 30 mins incubation absorbance was checked at 415 nm (Maulana *et al*., 2019) [16].

2.5.3 Antioxidant scavenging activity
The percent DPPH (1, 1-diphenyl-2-picrylhydrazyl radical) inhibition was measured for extracts to check presence of the antioxidants. 3 ml of methanol diluted DPPH (0.2 mM) was added to 1ml of sample and for control same volume of DPPH was added to 1ml methanol. The incubation period was 30 mins and absorbance of sample and control was checked at 517 nm (Cortellino & Rizzolo, 2018) [6].

2.6 Statistical analysis
The analysis was performed in triplicates and results are mentioned as mean ± standard deviation except for total soluble solids as there was not any deviation in the readings. The statistical analysis was performed in Minitab statistical software using One-way ANOVA (Post-hoc Tukey test) at a significance level of 0.05.

3. Results and Discussion
The results of the evaluation of both extracts along with indications of statistical analysis are mentioned in table 1.

3.1 Physicochemical properties of dryer extract compared with hydrodistillation extract
3.1.1 Colour
The L* value representing lightness/darkness was 2.46 and 3.48, a*(redness/greenness) -0.12 and -0.07, b* (yellowness/blueness) -0.59 and -0.34 for distillation and dryer aqueous extracts respectively. These values were correlated with colour charts and extracts colour was determined. Negative a* and b* values indicate that colour of extracts has slight greenish and bluish colour shade. The a* value for both did not show any significant difference unlike L* and b* values. More or less similarity was observed in colour of both extracts.

3.1.2 pH
The pH readings of extracts were near to neutral that is 6.61 for extract collected from dryer and 7.61 for hydrodistillation extract. Hydrodistillation extract pH is higher slightly than neutral and slightly lower for dryer extract. These values indicate that extracts have pH similar to that of distilled water. As previously studied, hydrosols collected from plant material distillation shows pH in same range that is 6.1 to 6.9 (Harcourt & State, 2020) [11].

3.1.3 Total Soluble Solids
Total soluble solids of extracts were checked for determining presence of solid content. It was found that both extracts were having very low total soluble solids and refractive index was same that is 0.1% Brix. This value is near to the total soluble solids reading of infusion which is 0.2% Brix (Nur *et al*., 2019) [17].

3.1.4 Specific gravity
Specific gravity was checked to confirm that water vapours evaporated during drying and distillation were collected and the extract was of aqueous form. These values are unitless and for both extracts it came as 0.96 and 0.98. (Harcourt & State, 2020) [11] has evaluated specific gravity of hydrosol and paint manufactured by adding hydrosol in it. They have found that hydrosol specific gravity is lower than one and is according to the standard value.

3.2 Bioactive properties of dryer extract in comparison with hydrodistillation extract
Bioactive properties were studied by measuring phenolic content, flavonoid content and antioxidant scavenging activity of extracts. Analysis results showed positive results and are mentioned below.

3.2.1 Total phenolic content
Phenolic content of distillation extract was higher than that of dryer extract that is 6.07 and 5.04 Gallic acid equivalent mg/100 ml correspondingly. (Ulusoy *et al*., 2009) [22] conducted study on extracts of rose including distillation hydrolat and oil and results showed that phenolic content is widely ranged between 5.2 to 2134.3 Gallic acid equivalent mg/1000 ml. This supports the results obtained for dryer and distillation extracts phenolic content of ash gourd.

3.2.1 Total flavonoid content
Flavonoids content was measured as Quercetin Equivalent mg/100 mL and was found to be 4.1 and 4.94 Quercetin Equivalent mg/100 mL in the extracts. (Chester *et al*., 2017) [5] has evaluated various extracts of moringa seeds including water extract and the total flavonoid content obtained for these extracts is from 0.8 to 9.8 Quercetin equivalent mg/g of sample. The values obtained during this study falls in this range.

3.2.3 Antioxidant scavenging activity
Antioxidant scavenging activity was measured by percent DPPH inhibition. It also showed similar trend of higher value for distillation extract (4.28%) than dryer extract (2.43%). (Aydin, 2021) [2] analysed herbal waters that is aqueous extracts of distillation for various properties and one of them was antioxidant activity. The percent inhibition obtained in this study at different concentrations and of different herbs ranged from 2.68 to 54.50%. The results for ash gourd extracts are towards the lower end of this range.

Table 1: Physicochemical and bioactive properties of aqueous extracts

		HDAG	VDAG
Colour	L*	2.46 ± 0.011^{b}	3.58 ± 0.07^{a}
	a*	-0.12 ± 0.05 ^{a}	-0.07 ± 0.05 ^{a}
	b*	-0.59 ±0.07 ^{b}	-0.34 ± 0.07 ^{a}
pH		7.61 ± 0.027 ^{a}	6.61 ± 0.08 ^{b}
TSS		0.1	0.1
Specific gravity		0.96 ± 0.006 ^{b}	0.98 ± 0.001 ^{a}
TPC		6.07 ± 0.31 ^{a}	5.04 ± 0.23 ^{b}
TFC		4.94 ± 0.45 ^{a}	4.1 ± 0.66 ^{a}
DPPH activity		4.28 ± 0.11 ^{a}	2.43 ± 0.17 ^{b}

Values are mentioned as mean ± standard deviation and different letters in superscript indicates significant difference among means

HDAG: Hydrodistillation ash gourd extract, VDAG: Vacuum Dryer ash gourd extract, TSS: Total Soluble Solids, TPC: Total phenolic content as GAE mg/100mL, TFC: Total flavonoid content as Quercetin Equivalent mg/100 mL, DPPH: Percent DPPH inhibition

4. Conclusion
The water vapours escaped from the raw material during

drying were trapped and analysed for various parameters including colour, pH, Total soluble solids, Specific gravity and bioactive properties like total phenolic content, total flavonoid content and percent DPPH inhibition. For comparison, Hydrodistillation aqueous extract (hydrolat) was analysed for same parameters. Though there is statistical difference between extracts on comparison, the difference is very low. There was the presence of phenolics, flavonoids and antioxidants in extracts and hence can be used in food product development like flavoured drinks and others.

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