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Comparative Drying Study and Quality Evaluation of Cauliflower Leaf Powder

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ABSTRACT

This study presents the comparative analysis of drying methods and quality evaluation of cauliflower leaf powder. The project focused on cauliflower leaves, often discarded as waste despite being highly nutritious. This project was aimed to assess the effectiveness of different drying techniques in preserving the quality attributes of cauliflower leaf powder for potential food and nutritional applications. Cauliflower leaves were dried using hot air oven drying and tray drying techniques. The quality parameters were evaluated for fresh and stored powder. The drying curves obtained from both methods revealed distinct drying behaviours, with the hot air oven exhibiting a higher initial drying rate, while the tray dryer achieved a shorter drying time i.e., 1hr 45min. The moisture content of the cauliflower leaf powder decreased significantly with drying time in both methods. Quality evaluation of the dried cauliflower leaf powder included analyses such as colour, moisture, ash, iron, calcium, vitamin C, microbe load. The fresh tray dried powder was high in moisture 4.725%, ash 14.6%, iron 15.23±5.491mg/100g, vitamin C 2.403mg/100g and hot air oven dried powder was high in calcium 40mg/100g. The stored tray dried powder was high in ash 13.8%, iron 9.369±5.98mg/100g, vitamin C 1.455mg/100g, whereas the 3 months stored hot air oven powder was high in moisture 9.831% and calcium 23.255mg/100g. The microbe load which was observed for 3 months indicated the microbe load was higher in tray dried powder than hot air oven dried powder. In conclusion, by considering the yield, drying time, drying rate, quality analysis tray dryer technique was found to be better than hot air oven technique for the preparation of cauliflower leaf powder.

Keywords: *Cauliflower leaf, tray dryer, hot air oven, drying curve.*

1. INTRODUCTION

Cauliflower, scientifically known as Brassica oleracea var. botrytis, is a versatile and nutritious vegetable belonging to the cruciferous family. Renowned for its distinctive white head, known as the "curd" or "head," cauliflower is revered for its culinary flexibility, health benefits, and intriguing history. The vegetable's head, comprised of tightly clustered, undeveloped flower buds, is the most prized part for consumption. Cauliflower is grown in various parts of India, including states like Punjab, Maharashtra, Haryana, and Uttar Pradesh. Its cultivation requires a cool climate, adequate sunlight, and well-drained soil. Cauliflower is available throughout the year in Indian markets, with peak availability during the winter season. It's mild, slightly nutty flavour and firm texture make it a sought-after ingredient in diverse cuisines, where it can be enjoyed raw, roasted, steamed, or incorporated into dishes like stir-fries, soups, and salads. In India, cauliflower is celebrated for its versatility in various regional cuisines. From the famous "Gobi Manchurian" in Indo-Chinese cuisine to the comforting "Aloo Gobi" (cauliflower and potato curry) in North India and the aromatic "Gobi Masala" in South India, cauliflower adapts wonderfully to diverse cooking styles and flavours across the country. Beyond its culinary usage, cauliflower holds cultural significance. It's often included in festive dishes and special occasions, symbolizing prosperity and abundance in some traditions.

1.1 Health benefits of cauliflower

Cauliflower provides several health benefits. It supports digestive health; the high fiber content in cauliflower supports digestive health by promoting regular bowel movements and aiding in maintaining a healthy gut flora. It contains anti-inflammatory properties, compounds present in cauliflower possess anti- inflammatory properties, potentially reducing inflammation and lowering the risk of chronic diseases. It helps in weight management, low in calories and high in nutrients, cauliflower can be a valuable addition to weight management diets, offering satiety without excessive calories.

1.2 Cauliflower leaves

However, beyond the commonly consumed head, the cauliflower plant offers an often overlooked yet equally valuable component - the cauliflower leaves. While the head takes the culinary spotlight, the leaves, with their rich green hue and robust structure, possess their own array of nutritional benefits. Often discarded or underutilized, these leaves are not only edible but also nutritious, containing vitamins, minerals, and antioxidants that complement the health benefits found in the head. Cauliflower leaves are green leaves that cover cauliflower and often are sold along with the entire cauliflower. These are crisp green leaves that have a strong flavour and are used along with the stems. These are edible curly green coloured leaves that range from small to large sized leaves and have many culinary uses. They are widely used in salads, soups and etc. Cauliflower leaves are easy to collect. They are highly perishable due to their high moisture content. Cauliflower leaves are versatile and can be utilized similarly to other leafy greens like kale or collard greens. They can be cooked, sautéed, or added to soups and stews, offering a slightly peppery taste and a delightful texture. Cauliflower leaves is also rich source of dietary fiber, vegetable provide substantial quality of nutrients i.e. vitamins and minerals which help in preventing various diseases (Verhaegen, 1993). The leaves contribute about 50% of the total production of cauliflower [3]. They are rich source of carotene, ascorbic acid, riboflavin, folic acid and minerals like calcium, iron and phosphorous [5] adding a layer of sustainability by minimizing food waste. In recent years, there has been a growing appreciation for reducing food waste and maximizing the use of all parts of vegetables like cauliflower, including their leaves. This shift in perspective aligns with sustainable practices and encourages a more holistic approach to food consumption. Its inclusion in recipes diversifies culinary creations, infusing dishes with an earthy essence and a nutritional boost. From Savoury stews to healthful smoothies, this powder transcends its humble origins, elevating gastronomic experiences while bestowing the body with the gifts of calcium and iron.

1.3 Nutritional information

From the book "Nutritive Value of Indian Foods" by National Institute of Nutrition, cauliflower leaves contain 80g% moisture, 5.9g protein, 1.3g fat, 3.2g minerals, 2.0g crude fiber, 3.4g dietary fiber, 7.6g carbohydrates, 66Kcal energy [1], 96.74 ±16.41 calcium, 41mg iron and 52.84mg of vitamin C per 100g of leaves.

Cauliflower leaves are highly beneficial. They are nutritious, cheap and also plays a role in sustainability which in turn reduces food waste. Cauliflower leaves are good source of minerals and vitamins.

They mainly contain:

- Calcium
- Iron
- Vitamin C
- Vitamin K
- Fiber
- Antioxidants

- ► First and foremost, the remarkable richness of calcium within cauliflower leaf powder heralds its significance in fortifying skeletal health. Calcium, an elemental cornerstone for bone strength and structure, resides abundantly within these leaves. Through meticulous processing into powder form, this nutrient becomes more accessible and versatile, serving as a convenient dietary supplement or ingredient infusion into various culinary delights.
- ► Furthermore, the bounty of iron encapsulated within cauliflower leaf powder fortifies its nutritional prowess. Iron, crucial for oxygen transportation and cellular function, often eludes adequate intake in various dietary regimes. However, this verdant powder offers a robust solution, providing a natural source of this vital mineral. Its integration into everyday meals or as a supplement presents an accessible means to combat iron deficiencies and their associated health implications.
- ► Cauliflower leaves contain essential vitamins like vitamin K, which supports bone health and blood clotting, and vitamin C, an antioxidant that boosts the immune system and aids in skin health.
- ► They are a good source of dietary fiber, aiding in digestion, promoting gut health, and supporting regular bowel movements.
- ► These leaves contain various antioxidants, such as beta-carotene, which helps neutralize harmful free radicals in the body, reducing oxidative stress and potentially lowering the risk of chronic diseases.
- ► Some studies suggest that the compounds found in cauliflower leaves may possess anti- inflammatory properties, which could be beneficial in reducing inflammation in the body.
- ► They are low in calories but nutrient-dense, making them a good addition to a balanced diet, especially for those looking to manage their weight while still obtaining essential nutrients.

1.4 Aim

This study aims to compare drying techniques used and conduct quality evaluation for cauliflower leaf powder.

1.5 Objectives

1. To conduct drying of fresh cauliflower leaves by two drying techniques.
2. To conduct proximate analysis of developed powder.
3. To determine nutritive value of developed powder.
4. To determine microbial quality of developed powder.

2. LITERATURE REVIEW

Sagarika Chakraborty1 *, Santa Datta (De) 2. Estimation of Macro-Nutrients in Domestically Processed Cauliflower Leaf Powder. International Journal of Science and Research (IJSR) ISSN (Online): 2319- 7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

They estimated macro-nutrients in domestically processed Cauliflower Leaf powder. Fresh cauliflower leaves were collected, dried(roasting) and powdered. The analysis includes estimation of moisture, fat, crude fiber, energy, protein, carbohydrate, ash, indicates it is rich in energy, protein and minerals. Quantitative estimation of macronutrients in domestically processed dry cauliflower leaf powder (CLP) indicates that it is rich in energy, protein and minerals which can be used to enrich common recipes like roti, puri, paratha, soup, besan, dal etc. Cauliflower leaves, which are generally thrown away, can be utilized to improve the nutritional status of the population.

***Sagarika Chakraborty, Arpita Mandal, Kinka Mondal and Santa Datta (De). PREPARATION OF CALCIUM-DENSE CAULIFLOWER LEAF POWDER BY DIFFERENT METHODS & SELECTION OF THE MOST SUITABLE METHOD, International Journal of Current Research Vol. 7, Issue, 09, pp.20462-20468, Sept, 2015.**

The study was about preparation of calcium dense cauliflower leaf powder by different methods and selection of most suitable method. The powder was prepared by drying in five different ways: sun-drying, shade- drying, microwave-drying, oven-drying and roasting methods. All drying methods produced good quality powder but the total yield and calcium contents of powder samples varied as the processing method varies. Among the samples, oven dried CLP contain lowest amount of calcium whereas sun dried CLP contain highest amount of calcium. All the processed leaves have significantly higher calcium content. Roasting is the best method for the preparation of cauliflower leaf powder, considering all the advantages and disadvantages of five processing methods used. It is suggested that roasted dry CLP can be used as vegetable calcium supplement which can easily be incorporated into the many recipes commonly used in the day- to- day menu of the people.

Shivani A. Pankar and Deepak T. Bornare. Studies on cauliflower leaves powder and its waste utilization in traditional product. International Journal of Agricultural Engineering | Volume 11 | Sp. Issue | April, 2018 | 95-98.

This review studied on the nutritional composition of cauliflower leaves powder and its utilization into traditional product. Study was carried out on some recipes like idli, dhokla, pancake, biscuit, and noodles. Cauliflower leaves is good source of dietary fiber, minerals, iron and beta carotene. Being rich in essential micronutrients the green leafy vegetables can be utilized for the purpose of enrichment of nutritional deficient products. Cauliflower leaves powder can be used in traditional products for value addition purpose to overcome the health- related problems and anaemia diseases prevent.

Towseef A. Wani and Monika Sood*. Effect of incorporation of cauliflower leaf powder on sensory and nutritional composition of malted wheat biscuits. Vol. 13(9), pp. 1019-1026, 26 February, 2014 DOI: 10.5897/AJB12.2346 ISSN 1684-5315 ©2014 Academic Journals.

The malted wheat flour was blended with cauliflower leaf powder in the ratios of 10, 20 and 30% for the development of biscuits. The developed products were stored for 90 days to ascertain the changes in proximate composition and sensory characteristics. The highest moisture, crude protein, crude fiber and ash content of 1.68, 9.49, 13.32 and 1.49% were recorded in biscuits prepared from 70:30: malted wheat flour: cauliflower leaf powder, respectively. However, 100:00: whole wheat flour: cauliflower leaf powder recorded highest value of crude fat (21.96%). On the basis of sensory evaluation, biscuits prepared from 90:10: malted wheat flour: cauliflower leaf powder was adjudged the best with regard to their acceptability and storability.

Singh Sadhna*, Yadav Anjali and Agrahari Sony. Nutritional Evaluation and Sensory Characteristics of Products Developed from Waste Leaves of Cauliflower. Int. J. Curr. Microbiol. App. Sci (2018) Special Issue-7: 4782-4790.

Total six recipes namely fara, sweet biscuits, ladoo, salty biscuits, and rava idli supplemented with up to 15 per cent Cauliflower leaf powder (CLP) were tried. Supplementation of CLP up to 10% was most acceptable in fara, and ladoo whereas, in sweet biscuits and salty biscuits supplementation up to 5% was most liked by the panel members. On supplementation with cauliflower leaves powder the energy value of almost all the products decreased whereas, the iron content in fara, sweet biscuits, ladoo and salty biscuits increased respectively on 15% supplementation.

3. MATERIALS & METHODS

3.1 Materials

- The raw material required was cauliflower leaf.
- These leaves were available in local markets, and freshly discarded cauliflower leaves were collected.

3.2 Methods

- The drying of fresh cauliflower leaves was completed by two different methods i.e., by using tray dryer and hot air oven at 70°C.
- Trial experiment was conducted for estimation of drying time of each method.

3.2.1 Drying flow sheets

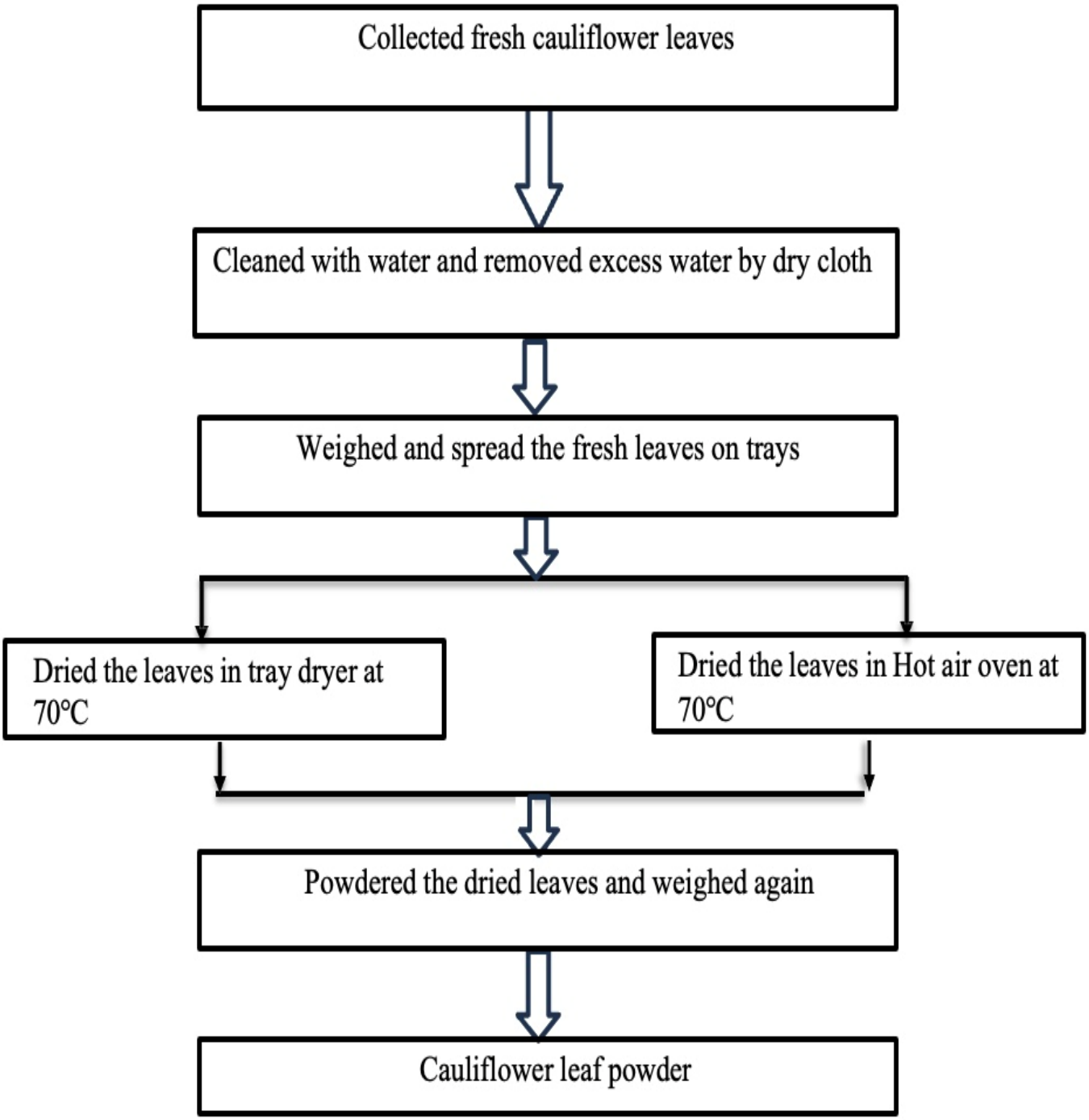


Fig. 1 Tray dried powder

Fig. 2 Hot air oven dried powder

The developed powder was stored in aluminium foil sheets for 3 months to conduct the final analysis.

Fig. 3 Storage of cauliflower leaf powder in aluminium foil sheet

3.3 Equipment and apparatus used

3.3.1 Equipment used for drying

Two equipment's were used for drying of cauliflower leaves.
They were:

- Tray dryer

Fig. 4 Tray dryer

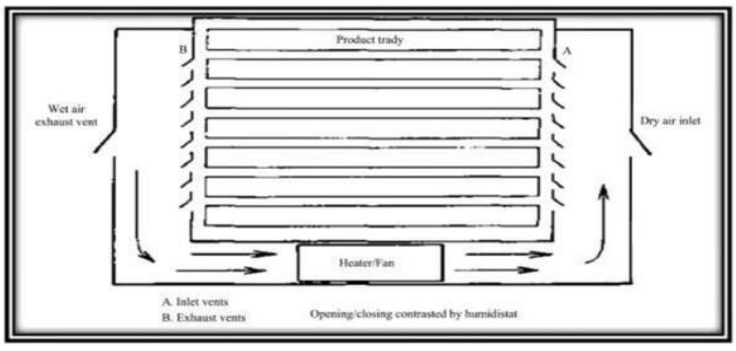


Fig. 5 Schematic diagram of tray dryer

- Hot air oven

Fig. 6 Hot air oven

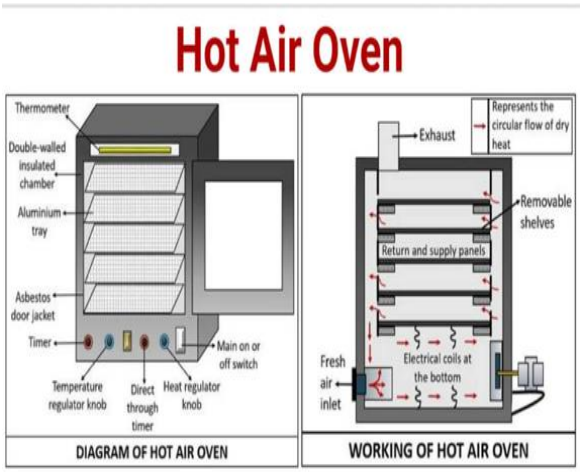


Fig. 7 Schematic diagram of hot air oven

3.3.2 Apparatus required for drying and to conduct the analysis

- Weighing balance
- Tray
- Petri plates
- Crucible
- Spatula
- Conical flask & beaker
- Burette
- Hot plate
- Volumetric flask
- Pipette
- Filter paper & funnel
- Test tubes
- Sterile spreader or glass rod

Fig. 8 Weighing balance

Fig. 9 Petri plate

Fig. 10 Crucible

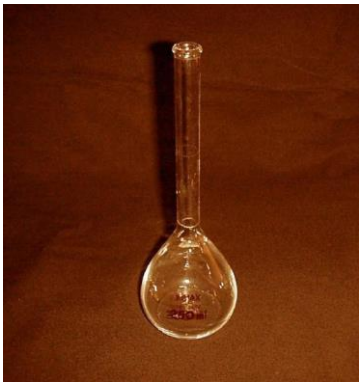


Fig. 11 Hot plate

Fig. 12 Volumetric flask

Fig. 13 Conical flask

3.3.3 Equipment to conduct analysis for Quality evaluation of developed Cauliflower Leaf Powder

- Hot air oven
- Muffle furnace
- Spectrophotometer for colour analysis
- Centrifuge
- Spectrophotometer
- Incubator
- Colony counter
- Laminar air flow

3.4 Analysis to be conducted for quality evaluation of developed cauliflower leaf powder

The analysis to be conducted were classified into 4 categories.
They were:

Proximate analysis:

- Moisture
- Ash

In proximate analysis, determination of moisture content and determination of ash content were done.

Physical analysis:

- Colour

In physical analysis, determination of color by spectrophotometer was done.

Nutritive value analysis:

- Calcium
- Iron
- Vitamin C

In nutritive value analysis, estimation of calcium content, estimation of amount of iron, and estimation of vitamin C by 2,6 Dichlorophenol Indophenol dye method were done.

Microbial quality analysis:

- Microbial load

In microbial quality analysis, Determination of microbial load was done.

The proximate, physical, and nutritive value analyses were to be conducted initially and finally after storing for 3 months. The microbial quality analysis was to be conducted once a month.

3.4.1 Proximate analysis

3.4.1.1 Determination of moisture content

Apparatus:

- Petri plate dishes
- Hot air oven
- Weighing balance

Desiccators containing efficient desiccants such as phosphorus pentoxide or calcium chloride.

Procedure:

Weigh accurately about 5 gm of sample in a previously dried and tared dish and place the dish with its lid underneath in the oven for 2 hours. The time should be reckoned from the moment the oven attains 130°C after the dishes have been placed. Remove the dish after 2 hours, cool in the desiccators and weigh. The dish should be placed back in the oven at half hour intervals till constant weight is achieved.

Moisture Percent = [(W1-W2)/(W1-W) x 100]

Where,

W1 = Weight in gm of the dish with the material before drying,

W2 = Weight in gm of the dish with the material after drying

W = Weight in gm of the empty dish.

Fig. 14 Hot air oven

Fig. 15 Moisture content analysis

3.4.1.2 Determination of ash content

Apparatus:

- Porcelain crucibles
- Electric muffle furnace, capable of maintaining a temperature of 625 ± 25°C. Ensure enough oxygen is admitted to the chamber to complete removal of the carbonaceous material
- Desiccators

Procedure:

About five grams of the sample was weighed accurately into a porcelain crucible and charred. This was transferred into a muffle furnace set at 600°C and left for about 4 hours. About this time it had turned into white ash. The crucible and its content were cooled to about 100°C in air then to room temperature in desiccators and weighed.

The percentage ash was calculated from the formula below,

%Ash (dry basis) = (weight of crucible and ash – weight of empty crucible/ weight of crucible and sample – weight of empty crucible) x 100.

Fig. 16 Samples taken for ashing

Fig. 17 Ash of the samples

Fig. 18 Charred sample

Fig. 19 Muffle furnace

3.4.2 Physical analysis

3.4.2.1 Determination of colour by spectrophotometer

Add cauliflower leaf powder uniformly in the sample holder. Place the sample holder on the rotating platform. Use the given pencil and operate the spectrophotometer. The colour values and graph will be displayed on the screen.

Fig. 20 Spectrophotometer

Fig. 21 Tray dryer dried powder colour analysis

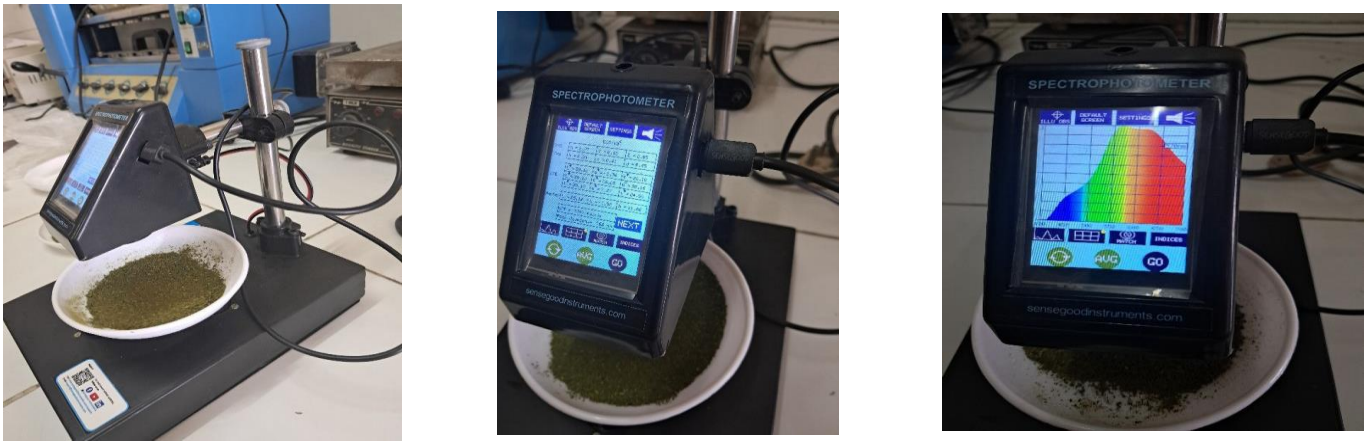


Fig. 22 Hot air oven dried powder colour analysis

3.4.3 Nutritive value analysis

3.4.3.1 Estimation of calcium content

Apparatus:

- Conical flask
- Burette
- Tripod stand
- Centrifugation tube

Reagents:

1. 4% Ammonium oxalate solution
2. Dilute Ammonium solution
3. 1N H_2SO_4
4. 0.01N $KMnO_4$ solution
5. 0.01N oxalic acid
6. Standardization of $KMnO_4$ solution
7. HCL (AR grade)
8. Whatman number 40 filter paper

Preparation of mineral solution:
First, prepare the ash by using muffle furnace. The ash is moistened with a small amount of distilled water (0.5-1ml), 5ml of dil. HCL is added and solution is evaporated to dryness then 4ml of HCL, few ml of distilled water is added again. The solution

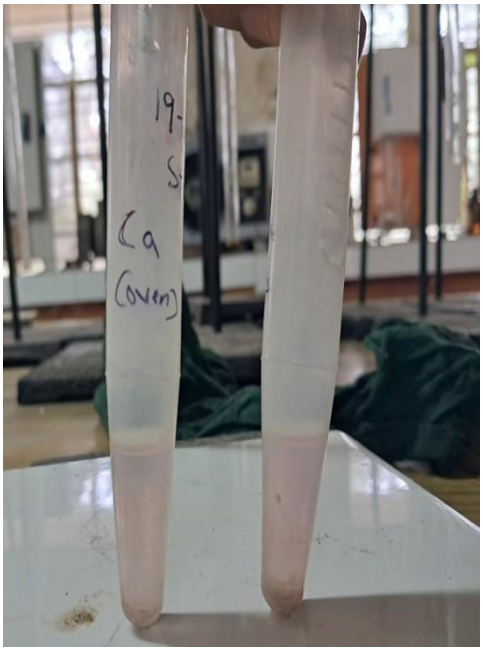
is warmed over a boiling water bath and filtered into a 100ml volumetric flask using Whatman number 40 filter paper. After cooling, the volume is made up to 100ml with distilled water and suitable aliquots are used for estimation of calcium or iron.

Procedure:

Blank: Take 2ml of 1N H2SO4, heat and titrate with KMnO4 to end point pink color.
Standardization: Take 25ml 0.01N oxalic acid in conical flask. Add 1ml of conc H2SO4, heat at 70°C for few minutes and titrate against 0.01N KMnO4 till pink color is seen.
Sample: 2ml of sample was taken in a centrifuge tubes, add 2ml of distilled water and 1ml of 4% ammonium oxalate solution, mix thoroughly and leave overnight. The contents are mixed and centrifuged for 5min at 1500RPM. The supernatant liquid was poured off and the centrifuge tube was drained by inverting the tube for 5min on a rack. The mouth of centrifuge tube was wiped with a piece of filter paper. The precipitate is stirred and the sides of the tubes are washed with 3ml of dil NH3. It is centrifuged again and drained as before. The precipitate was washed once more with dil NH3 to ensure complete removal of ammonia oxalate. The precipitate was dissolved in 2ml of 1N H2SO4. The tube was heated by placing it in a boiling water bath for 1min and titrate against 0.01N KMnO4 solution to a definite pink color persisting for at least 1min. 1 ml of 0.01N KMnO4 is equivalent to 0.2004 mg of Calcium.

Mg of calcium present in 100g of sample = (Titre value x 0.2 x total volume of ash solution x 100)/(volume taken for estimation x weight of sample taken for ash)

Fig. 23 Centrifugation tube



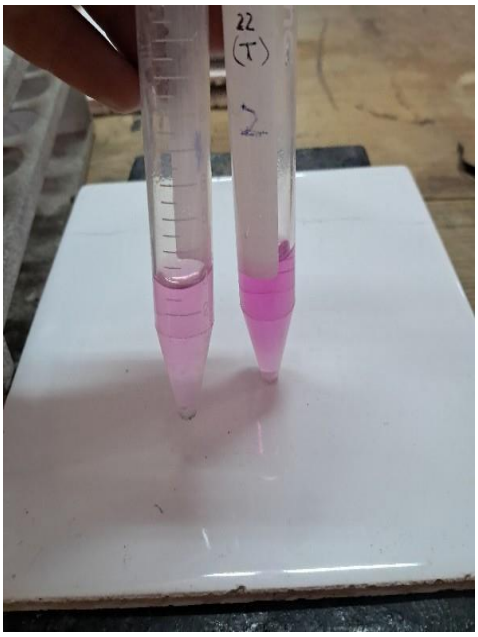


Fig. 24 Calcium analysis

3.4.3.2 Estimation of amount of iron

Reagents:

1. 30% H_2SO_4
2. 7% Potassium per sulphate solution
3. 40% Potassium thiocyanate (KCN)
4. Standard iron solution
5. Working standard solution

Procedure:
To an Aliquot 0.5ml or 1ml of mineral solution add 6ml of glass distilled water to make to volume of 6.5 ml followed by 1ml of potassium per sulphate add 1.5 ml 40% KCN solution. The red colour that develops is measured within 20 min at 540nm. For unknown sample the concentration of iron in the Aliquot of the sample. Then read directly from the graph after measuring OD values.
Mg of Iron present in 100g of sample = (OD of sample x Conc^n of std x total volume of ash x 100) / (OD of std x volume of solution for estimation x weight of sample taken for ash)

Fig. 25 Spectrophotometer

Fig. 26 Iron analysis

3.4.3.3 Estimation of Vitamin C by 2,6 Dichlorophenol Indophenol Dye method

Reagents:

1. 3% metaphosphoric acid
2. Ascorbic acid standard
3. Working standard
4. Dye solution

Procedure:

Standardization: Take 5ml of standard ascorbic acid solution and add 5ml of metaphosphoric acid. Fill the micro burette with dye; titrate with dye solution to a pink colour which should persist for 15 sec. Determine the dye factor in mg of ascorbic acid per ml of the dye.
Sample: First, prepare the sample by adding 10g of sample in 3% metaphosphoric acid and make up to 100ml with 3%metaphosphoric acid, filter and centrifuge. Take 5ml of sample in a conical flask and titrate with the dye, end point is pink colour.
Dye factor = 0.5 / titre value of standardization

Ascorbic acid per 100g of sample = (titre value of sample x dye factor x volume made up x 100) / (aliquot of extraction for estimation x volume of sample taken)

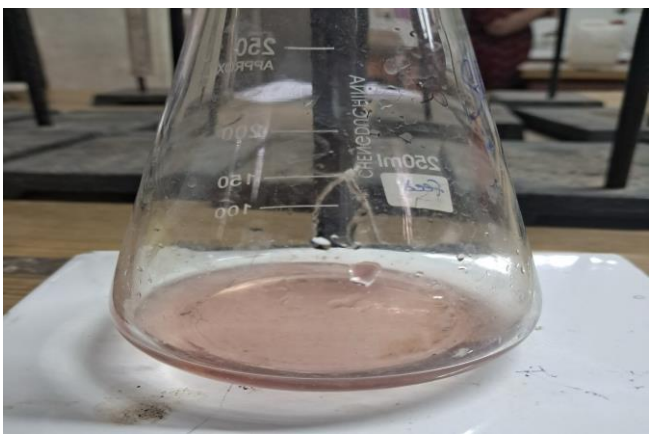


Fig. 27 Vitamin C analysis

3.4.3 Microbial quality analysis

3.4.4.1 Determination of microbial load

Apparatus:

- Petri plate
- Test tube
- Measuring cylinder
- Stirrer
- Beaker
- Pipette

Procedure:

Prepare a 250ml nutrient agar medium by taking 10g of agar and 250ml of water. Sterile all apparatus, agar medium, water in autoclave at 121℃ for 15min. Immerse the sample in sterile water for 15min, mix using stirrer and then transfer 1ml of water to first tube, containing 9ml of sterile water using pipette. Serial dilution continues up to 4 tubes. Pour agar medium into petri plates and let it be solidified. Inoculate 0.1ml using micro pipette from each dilution into solidified agar plate, spread evenly using a sterile spread. Incubate the inoculated agar plates in incubator at 37℃. Observe the microbial growth at regular intervals. Count the number of colonies using a colony counter after 24 hours of incubation. Calculate CFU/mL for specific dilutions.
Colony unit count (CFU/mL) = (number of colonies x dilution factor)/(volume of culture plate)

Fig. 28 Colony counter

Fig. 29 Laminar air flow

Fig. 30 Laboratory incubator

Fig. 31 Microbe growth

Fig. 32 Autoclave sterilization

Fig. 33 Incubation

4. RESULTS AND DISCUSSIONS

- Trial experiment was done.

4.1 Drying time

Table 1: Drying time

S. No	Drying method	Drying time (min)
1	Tray Dryer	1hr 45min
2	Hot Air Oven	2hr 15min

- The drying time of cauliflower leaves was less in a tray dryer when compared with a hot air oven.
- The drying time in tray dryer was 1hr 45min and in hot air oven it was 2hr 15min, the drying time in tray dryer was 30min earlier than hot air oven.

4.2 Yield

Table 4.2: Yield

S. No	Drying method	Weight of fresh leaves (g)	Weight of powder (g)	Yield (%)
1	Tray dryer	100	14	14
2	Hot air oven	100	11.73	11.73

- The yield percentage of cauliflower leaf powder in a tray dryer was 14% whereas in hot air oven it was 11.73%.
- The yield of the cauliflower leaf powder was more in a tray dryer than in hot air oven.
- The yield percent in tray dryer was 2.27% more than the yield in hot air oven.
- Developed cauliflower leaf powder and conducted quality analysis on fresh cauliflower leaf powder and stored cauliflower leaf powder.

4.3 Drying rate table

4.3.1 Tray dryer

empty tray weight = 2.494kg
area of tray = 2450cm^2 = 0.245m^2
drying rate (kg/hm^2) = (weight at initial time-weight at t time)/(area of time x ‘t’ time)

Table 4.3: Drying rate of tray dryer

Time (min)	Weight of tray with sample (kg)	Drying rate (kg/hm^2)
0	2.546	-
15	2.532	228 x 10^{-3}
30	2.520	192 x 10^{-3}
45	2.511	146.4 x 10^{-3}
60	2.507	64.8 x 10^{-3}
75	2.501	97.8 x 10^{-3}
90	2.498	48.96 x 10^{-3}
105	2.498	0

- Drying rate of sample using tray dryer method was calculated. The drying rate ranged from 48.96 x 10^{-3} to 228 x 10^{-3} kg/hm^2.

4.3.2 Hot air oven

empty tray weight = 0.45kg
area of tray = 638.7cm^2 = 0.06387m^2
drying rate (kg/hm^2) = (weight at initial time-weight at t time)/(area of time x 't' time)

Table 4.4: Drying rate of hot air oven

Time(min)	Weight of tray with sample (kg)	Drying rate (kg/hm^2)
0	0.513	-
15	0.508	312.6 x 10^{-3}
30	0.499	563.4 x 10^{-3}
45	0.490	563.4 x 10^{-3}
60	0.478	750 x 10^{-3}
75	0.470	501 x 10^{-3}
90	0.464	375.6 x 10^{-3}
105	0.460	250.2 x 10^{-3}
120	0.459	62.58 x 10^{-3}
135	0.459	0

- Drying rate of sample using Hot air oven drying method was calculated. The drying rate ranged from 62.58 x 10^{-3} to 750 x 10^{-3} kg/hm^2.

4.4 Drying curve

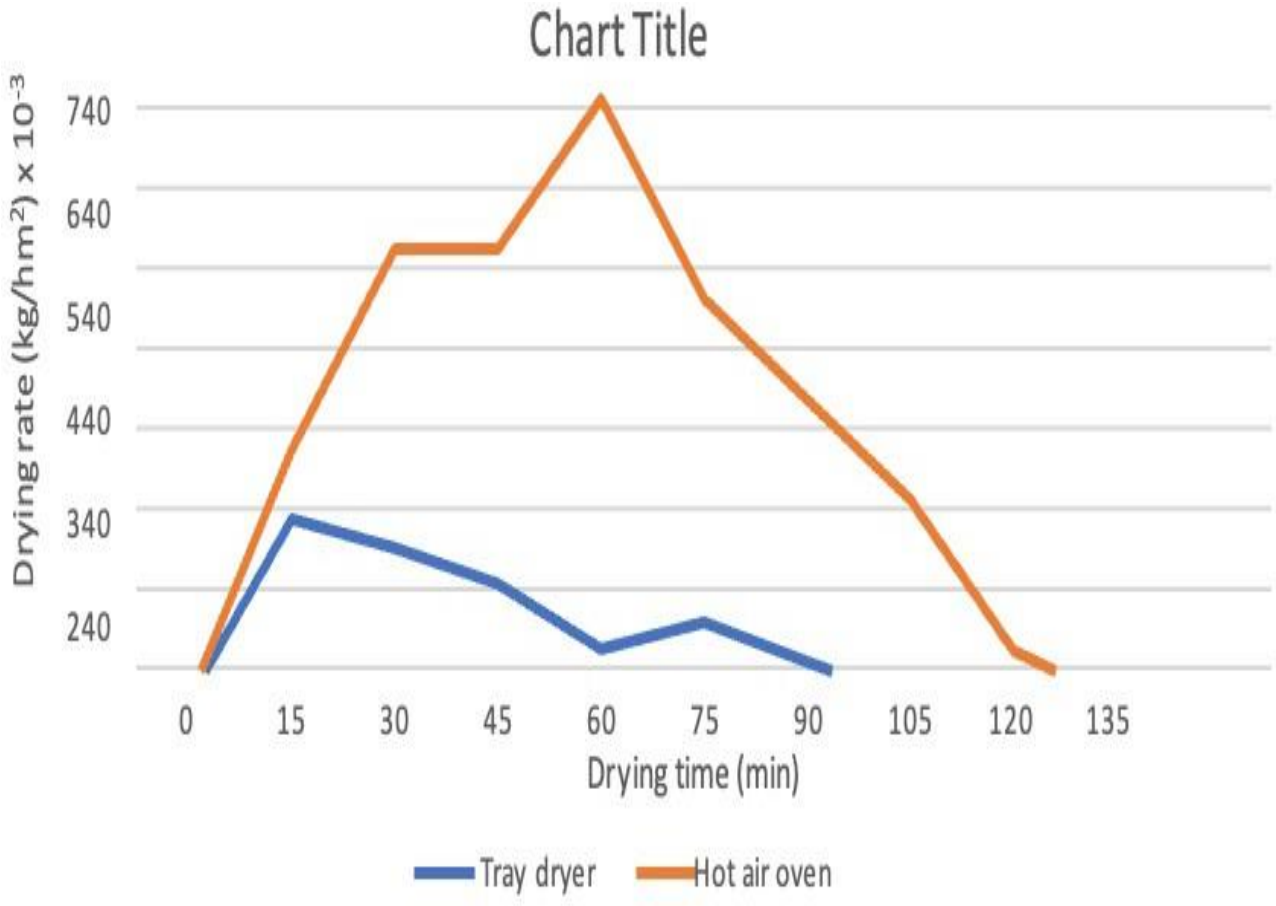


Fig. 34 Drying curve

- Drying curve was plotted against drying time v/s drying rate, respective drying curve of both drying methods were observed. The drying rate was at peak in hot air oven method at 60min with 750 x 10^{-3} kg/hm^2 and in tray dryer method at 15min with 228 x 10^{-3} kg/hm^2. The initial drying rate was high in hot air oven. The drying curve of hot air oven was higher than tray dryer. Tray dryer method had shortest drying time to remove the moisture content.

4.5 Result table of analysis

Table 4.5: Analysis result

S. No.	Analysis	Tray dried powder		Hot air oven dried powder	
		Initial	Final	Initial	Final
1	Moisture (%)	4.725	7.56	3.75	9.831
2	Ash (%)	10.2	9.4	9.6	8.6
3	Vit C (mg/100g)	2.403	1.455	0.5448	0.480
4	Iron (mg/100g)	15.23 ± 5.491	9.369 ± 5.98	14.802 ± 4.372	5.015 ± 3.949
5	Calcium (mg/100g)	20	19.677	40	23.255
6	Colour	L^* = 30.99, a^* = -5.54, b^* = 22.57	30.45, -2.34, 25.98	29.08, 0.87, 24.67	29.68, 1.08, 25.45

- Moisture: In initial analysis, the moisture percent was high in tray-dried powder at 4.725%, whereas the moisture in hot air oven-dried powder was 3.75%. In final analysis, the moisture percent was high in oven-dried powder at 9.831%, whereas the moisture in tray- dried powder was 7.56%. During the storage, moisture percent increased 2.835% in tray dried powder and 6.081% in hot air oven dried powder.
- Ash: In initial analysis, the ash percent was high in tray-dried powder at 10.2%, whereas the ash in hot air oven-dried powder was 9.6%. In final analysis, the ash percent was high in tray-dried powder at 9.4% than oven oven-dried powder at 8.6%. During the storage, ash percent decreased 0.8% in tray dried powder and 1% in hot air oven dried powder.
- Vitamin C: In initial analysis, the vitamin C was high in tray dried powder at 2.403mg/100g, whereas in hot air oven-dried powder it was 0.5448mg/100g. In final analysis, the vitamin C was high in tray dried powder at 1.455mg/100g, whereas hot air oven dried powder was 0.480mg/100g. During the storage, there was decrease of 0.948mg/100g in tray dried powder and 0.0648mg/100g in hot air oven dried powder.
- Iron: In initial analysis, the iron was high in tray dried powder at 15.23 ± 5.491mg/100g, whereas in hot air oven-dried powder it was 14.802 ± 4.372mg/100g. In final analysis, the iron was high in tray dried powder at 9.369 ± 5.98mg/100g, whereas hot air oven dried powder was 5.015 ± 3.949mg/100g. During the storage, there was decrease of 5.861±0.489mg/100g in tray dried powder and 9.787± 0.423 mg/100g in hot air oven dried powder.
- Calcium: In initial analysis, the calcium content was high in hot air oven dried powder at 40mg/100g than the tray dried powder which was 20mg/100g. In final analysis, calcium was high in hot air oven at 23.255mg/100g than the tray dried powder which was 19.677mg/100g. During the storage, the calcium content decreased rapidly in hot air oven dried powder by 16.745mg/100g, whereas it decreased slightly by 0.323mg/100g in tray dried powder.
- Colour: By observing the values of colour, the tray-dried powder was lighter, greener and less yellow than hot air oven-dried powder in both initial and final analysis.
- In initial analysis, moisture, ash, iron and vitamin C were more in tray dried powder than hot air oven dried powder except calcium.
- In final analysis, ash, iron and vitamin C were more in tray dried powder than hot air oven dried powder except calcium and moisture. Retention of calcium was better in tray dried powder

4.6 Result table of microbial load analyses

Table 4.6: Microbial load analysis result

Drying method	1^{st} month (CFUs/mL)	2^{nd} month (CFUs/mL)	3^{rd} month (CFUs/mL)
Tray Dryer	0.6×10^{-4}	0.8×10^{-4}	1.2×10^{-4}

Hot Air Oven	0.2×10^{-4}	0.6×10^{-4}	1.0×10^{-4}

- The microbe load was high in tray dried powder in the 1st month with 0.6×10^{-4} (CFUs/mL). The difference in the microbe load in 1st month between tray dried powder and hot air oven dried powder was 0.4 CFUs/mL.
- The microbe load was high in tray dried powder in the 2nd month with 0.8×10^{-4} (CFUs/mL). The difference in the microbe load in 2nd month between tray dried powder and hot air oven dried powder was 0.2 CFUs/mL.
- The microbe load was high in tray dried powder in the 3rd month with 1.2×10^{-4} (CFUs/mL). The difference in the microbe load in 3rd month between tray dried powder and hot air oven dried powder was 0.2 CFUs/mL.

5. CONCLUSIONS

The cauliflower leaves were dried by using two different drying techniques i.e., tray dryer and hot air oven. Successfully developed the powder of the cauliflower leaves which generally are discarded as a waste. Proximate, physical, nutritive value, and microbial load analyses were done for the fresh and stored cauliflower leaf powder. The microbe load was high in tray-dried powder during 3 months of storage when compared with hot air oven-dried powder. The initial analyses had shown that the values of moisture, ash, vitamin C, and iron were high in tray-dried powder except for calcium when compared to hot air oven-dried powder. The final analyses which were done after storing for 3 months showed that the values of ash, vitamin C, and iron were high in tray-dried powder except for moisture and calcium. Though the calcium value was less in tray- dried powder, the retention of calcium was more in tray-dried powder than in hot air oven-dried powder. The drying curve was higher for the hot air oven method than tray dryer method but the shortest drying time was observed in tray dryer method. By comparing the results from the quality evaluation, yield, and drying time, the tray dryer method was found to be better than the hot air oven dry method for the production of cauliflower leaf powder.

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