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Comparative analysis of the drying properties of moringa (*Moringa oleifera* L.) leaves, basil leaves and ginger

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Abstract
In this investigation, powder was produced by tray dryer drying at 60 °C and 65 °C for various time periods. Moringa leaves, basil leaves, and ginger were assessed for their drying properties, including moisture content, moisture ratio, and drying rate. In comparison to fresh leaves, drying ensures a decrease in water activity and improves the leaves' ability to retain moisture. Moringa, basil, and ginger leaves' moisture contents, moisture ratios, and drying rates are compared. After drying, ginger has the lowest moisture content (3.68% db), which took 0-420 minutes. The drying rate of ginger, basil, and moringa leaves was 3.05 g/min, 3.2 g/min, and 4.5 g/min, respectively, with moisture ratios of 1-0.44, 1-0.62, and 1-0.074.

Keywords: Powder, moisture content, moisture ratio, drying rate

1. Introduction

The family Moringaceae includes the species *Moringa oleifera*. It is a multipurpose tree that grows in tropical and subtropical regions of the world, including Bangladesh, India, Pakistan, and Sri Lanka. Both extreme drought and light frost don't harm moringa. (Gopalkrishnan *et al.*, 2016) [3]. In India, the plant is also referred to as drumstick, sahjan, or sohanjana. All plant components have a diverse spectrum of useful and beneficial characteristics. (Singh *et al*, 2012) [8]. With an annual production of 2.2 to 2.4 million tonnes of tender fruits from an area of 43600 hectares, India is the world's biggest producer of Moringa (Drumstick), with a yield of about 50 tonnes per ha. Fresh leaves (*Moringa oleifera*) have a relatively brief shelf life of only two to three days. In comparison to fresh leaves, drying ensures a decrease in water activity and improves the leaves' ability to retain moisture. In comparison to fresh leaves, dried leaves have an even higher concentration of micronutrients. Sun drying and tray drying are two common drying methods used for *M. oleifera* leaves. When leaves are dried using standard techniques, there are a number of drawbacks to consider, including a prolonged drying period, contamination of the product, loss of product quality coupled with loss of nutritional value. Dried leaves have even more micronutrients than fresh leaves. (Mishra *et al*., 2012) [10].

Although the powdered leaves of *Moringa oleifera* have not been used as a spice, numerous authors have noted the many advantages of this miracle plant. The leaves are a source of minerals, vitamins, and amino acids, according to studies. (Anjorin *et al.*, 2010) [1]. Moringa is a rich source of essential nutrients and antinutrients. The following nutrients can be found in moringa leaves: protein (31.64%), carbohydrates (38-60.75%), fat (6.95%), moisture (4.5%), ash (9.29%), and fibre (11.37%). Additionally, it contains minerals such as Iron (28 mg/100 g), Magnesium (368 mg), and Phosphorus (204 mg). Phytochemicals such sterols, terpenoids, flavonoids, saponins, and alkanoids are found in moringa. Tocopherol (17.3 mg/100 gm) and carotenoids (44.30–80.48 mg/100 gm) are abundant in the leaves of the *Moringa oleifera* plant. Glucosinolate, luteoxanthin, and alpha-carotene are also present. Flavonoids like kaempferol (0.05-0.67%) and quercetin (0.07-1.26%), which are flavanol glycosides (glucosides, rutinosides, mononyl glucosides). (Saini *et al.*, 2016) [9].

Due to their high perishability, moringa leaves must be processed in order to reduce post-harvest losses. This meant that preservation by treatment like drying prevents them from deteriorating quickly. Drying is a fantastic way to preserve Moringa leaves and turn them into powder, which makes it simpler to store and use whenever you want.

Although a significant portion of water-soluble vitamins are lost during drying and storage, leaf powder nevertheless represents a highly rich source of nutrients that are concentrated in the dried leaves. (Emelike and Ebere 2016) [2].

The Zingiberaceae family includes perennial herbaceous flowering plants like ginger (*Zingiber officinale*). It has a long history and is considered to be the oldest spice. This plant is utilised as a spice in food all around the world, both fresh and dried, to add flavour and spice to meals. (Jayashree *et al.*, 2011) [4]. Fresh ginger has a moisture content of 80.9%, 2.3% protein, 0.9% fat, 1.2% minerals, 2.4% fibre, and 12.3% carbs. Iron, calcium, and phosphorous are the minerals found in ginger. It also includes vitamins including thiamine, riboflavin, niacin, and vitamin C. (Kokani *et al*., 2019) [5].

An annual member of the mint family (Lamiaceae), basil (*Ocimum basilicum* L.) is a herb. The Ocimum genus encompasses a variety of 50 to 150 species and variations that are indigenous to the tropical regions of Asia, Central Africa, and South Africa. It has been used for millennia and is a crucial component in many cooking traditions and practises. The common names "basil" and "wild basil" are used for a variety of plants that are not members of the genus Ocimum, which can occasionally cause misunderstandings and confusion. (Lupton *et al.*, 2016) [6].

Basil and other hot herbs are used in food preparations for more than just flavouring due to their potent spicy scent; they are also used for their therapeutic, antioxidant, anti-inflammatory, antiviral, and antibacterial capabilities (Parmar *et al.*, 2017) [12].

2. Material and Methods
2.1 Material and Equipment
Raw materials *viz*., Ginger, (*Zingiber officinale*), Moringa (*Moringa oleifera)* leaves and Basil (*Ocimum basilicum)* leaves and packaging materials (Low density poly ethylene) were purchased from the local market of Meerut. Ginger, Moringa leaf and basil leaves collected from Horticulture Research Centre were prepared in Product Development Laboratory, College of Post-Harvest Technology and Food Processing, SVP University of Agriculture and Technology, Modipuram, Meerut.

2.2 Experimental Set up
This study was conducted in Product Development Laboratory, College of Post Harvest Technology and Food Processing, SVPUA&T Meerut, Uttar Pradesh, India. Various equipments and apparatus such as digital electronic balance, hot air oven, cabinet tray dryer, electronic grinder, drying rate, and moisture ratio were used during the experiments. All the equipments were kept in laboratory. They were set and adjusted for the experiments. Salient features of the major equipments used during the investigation are described below.

2.3 Electronic balance
Weighing of samples for analysis of moisture content, fat, protein, ash content etc. was carried out with the help of electronic balance. A top pan electronic balance of high accuracy with digital display (Samson, S300) was used. It has capacity of 1000 gm and least count 0.001gm. For larger quantities of products another electronic balance (Samson, S500) was used which had maximum capacity of 5 kg and least count 0.1 g.

2.4 Hot air oven
Hot air oven (Instron, IN-301 model) is a double walled chamber of size 78 cm×27 cm×116 cm. Outer chamber is made of mild steel while the inner chamber is made of stainless steel. 65 cm glass wool insulation is provided in between the two walls.

Heating elements are evenly placed in ribs on both sidewalls and rear wall for uniform heating. Air ventilators are provided on the sidewalls of the oven. A thermometer is provided at the front of the oven. The temperature is controlled by a thermostat. Perforated shelves are provided for the placement of samples on them. Oven was used for the measurement of moisture content of raw materials and products.

2.5 Tray dryer
A Cabinet type mechanical tray dryer (Industrial Dryer, M/s Navyug Udhyog Pvt. Ltd Ambala) was used to conduct drying experiment of pre-treated ginger, moringa and basil leaves. The heating air circulated inside the cabinet with the help of circulating fan. The thermostatic controller (50-250 °C) was also attached with the heating unit to control the desired temperature for the drying. The moringa leaves, basil leaves and ginger placed uniformly on stainless steel trays (80 cm length × 40 cm width and ~1.37 kg weight) and experiments were conducted at 60 °C and 65 °C temperature.

2.6 Electronic grinder
An electronic grinder (Bajaj) is used for the grinding purpose for the preparation of powder from dried moringa leaves, basil leaves and ginger.

2.7 Development of blended powder
The blended powder**s** were prepared in the following way and the flow chart is given in Fig.1

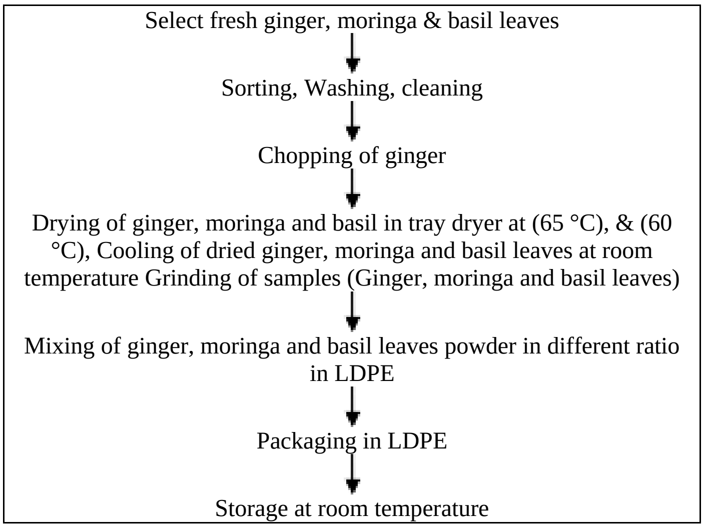

Fig 1: Process flow chart for development of blended powder

2.8 Drying Kinetics Analysis
2.8.1 Determination of Moisture Content
Moisture content of the sample was determined by standard oven method (Ranganna, 2001) [7]. Test sample of 5 g was kept for 24 h in a hot air electric oven maintained at 105 °C. After 24 h, sample was drawn from the oven and placed in a desiccator for cooling. After cooling, the weight of the sample was taken precisely. The loss in weight was calculated and moisture content was determined using the following formula.

$$M\ C\%\ (w.\ b) = \frac{(\text{Initial weight} - \text{Final weight})}{\text{Initial weight}} \times 100$$

2.8.2 Moisture Ratio

Moisture ratio is the ratio of the moisture content at any given time to the initial moisture content (both relative to equilibrium moisture content). Moisture Ratio was determined using following equation,

$$\text{Moisture Ratio (MR)} = \frac{(M - Me)}{M0 - Me} \times 100$$

Where,
M = given moisture content M0 = Initial moisture content
Me = Equilibrium Moisture Content (EMC)

2.8.3 Drying rate

Drying Rate is determined using following equation,

$$\frac{dm}{dt} = \frac{M2 - M1}{\nabla t}$$

Where,
Δt = difference in time

3. Result and Discussion

3.1 Drying Characteristics of moringa leaves, basil leaves and ginger

Using experimental data on product moisture at various time intervals in 60° C tray drying conditions, the drying behaviour of moringa, basil leaves, and ginger was examined. Table 1 contains experimental data on the drying behaviour of moringa, basil leaves, and ginger in relation to moisture content, moisture ratio, and drying rate.

Following the application of selected controls, the samples were dried to the final safe level of moringa leaves, basil leaves, and ginger moisture content, which is around 20.41% on dry basis (db), 135.48%, and 3.68% continuously on dry basis (db), according to the findings of the various researchers. (Van Arsdel and Copley, 1963) [11] Under various drying settings, the treated and untreated samples' moisture contents, moisture ratios, and drying rates for various times were compared.

3.2 Effect on moisture content of moringa leaves, basil leaves and ginger

According to preliminary investigations, the initial moisture content of moringa, basil, leaves and ginger was 81.30% (wb), 90.70%, and 80.9% (wb), respectively. Moringa leaves, basil leaves, and ginger's wet basis moisture content were consequently converted into dry basis and found to be, respectively, 423.56%, 975.26%, and 434.75% constantly. It is clear that at the beginning of the drying process, moisture content reduced quickly as drying time increased. Controlled samples dried to the lowest final moisture content at all drying temperatures. Since the surface of the material was initially wet, drying progressed more quickly as the air temperature rose. During the time when the rate of growth was decreasing, the material's surface was no longer completely saturated with water, and drying was regulated by the diffusion of moisture from the material's interior to the outside. Drying time was found to be longest for tray drying (420 min) and to decrease with temperature rise. Moringa leaves ranged from 20.41% (db) to 135.48% (db) to 3.68% (db) of ultimate moisture content, whereas basil leaves varied from that as well.

3.3 Effect on moisture ratio of moringa leaves, basil leaves and ginger

Table 1 illustrates the change in moisture ratio over time for an experimental temperature of (60 °C) during tray drying. The association demonstrates that during the first 0 to 420 min of drying in all cases, there was a rapid reduction in the moisture ratio of moringa leaves, basil leaves, and ginger before it slowed down. Later stages of drying, however, saw a slower rate of decrease in moisture ratio. The continuous ranges for the moisture ratios of ginger, moringa, and basil leaves were respectively 1 to 0.074, 1 to 0.617, and 1 to 0.44. The moisture ratio was one in each example at the beginning of drying, and it declines nonlinearly with each additional drying.

3.4 Effect on drying rate of moringa leaves, basil leaves and ginger

The estimated change in moisture content that happened in each successive time interval was used to compute drying rates from the observed data. Table 1 presents the calculated information on drying rate. It was to be assumed that temperature had an impact on drying speed. Higher temperatures, such as under tray drying at 60 °C, resulted in a faster drying rate. Moringa and basil leaves dried under tray drying for a total of 420 and 360 minutes, respectively, based on the controlled conditions. Higher temperatures, such as under tray drying at 65 °C, resulted in a faster rate of drying. According to table 3, which summarises the total drying time for ginger dried on trays at 65 °C, samples took 180–240 minutes to dry entirely, depending on the condition. Moringa leaves dried at a rate of 3.05 g/min, basil leaves dried at a rate of 3.216 g/min, and ginger dried at a rate of 4.5 g/min. Maximum drying took place in the first 0 to 120 minutes. After 120 minutes, the drying pace started to slow down. At around 120 minutes, it is evident that the drying rate is beginning to decline for the ginger, basil, and moringa leaves. After 180 minutes, the drying rate started to gradually decline and slowed down over time. Other experiments showed a comparable pattern. A non-linear relationship existed between drying time and a decline in drying rate. It was found that, as would be predicted, the drying rate increased with increasing temperature (under tray drying). However, there were a few places where curves interacted unexpectedly, and this was brought about by experimental modifications.

Table 1: Drying data for Moringa leaves dried under tray drier at 60 °C

Time (Min.)	Weight of sample (g)	Moisture Content (%db)	Drying Rate (g/min)	Moisture Ratio
0	1000	423.56	0	1
60	817	327.74	3.05	0.77
120	666	248.69	1.25	0.75
180	563	194.76	0.57	0.78
240	418	118.84	0.60	0.61
300	299	56.54	0.73	0.47
360	237	46	0.17	0.81
420	230	20.41	0.16	0.44

Table 2: Drying data for Basil leaves dried under tray drier at 60 °C

Time (Min.)	Weight of sample (g)	Moisture Content (%db)	Drying Rate (g/min)	Moisture Ratio
0	1000	975.26	0	1
60	807	767.74	3.12	0.78
120	657	606.45	1.25	0.78
180	554	495.69	0.57	0.81
240	409	339.78	0.60	0.68
300	288	209.67	0.40	0.61
360	228	145.16	0.16	0.69
420	219	135.48	0.024	0.93

Table 3: Drying data for ginger dried under tray drier at 65 °C

Time (Min.)	Weight of sample (g)	Moisture Content (%db)	Drying Rate (g/min)	Moisture Ratio
0	900	434.75	0	1
60	630	274.35	4.5	0.63
120	403	139.45	1.89	0.50
180	251	49.13	0.84	0.35
240	174	3.68	0.32	0.074

4. Conclusion

In conclusion, ginger was determined to have the lowest moisture content (3.68%) db when comparing the drying properties of moringa leaves, basil leaves, and ginger, it was found that the moisture content decreased quickly as the drying time increased. Moringa, basil, and ginger leaves all required 0-420 minutes to thoroughly dry out, with consistent readings of 1-0,44, 1-0,62, and 1-0.074. Moringa and basil leaves required the longest drying times (360–420 minutes) at temperatures of 60 °C, whereas ginger required the shortest drying times (180-240 minutes) at temperatures of 65 °C. Moringa leaves, basil leaves, and ginger dried at the fastest rates, respectively at 3.05 g/min, 3.2 g/min, and 4.5 g/min. After 120 minutes, drying rates begin to decline.

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