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EFFECT OF THE DRYING METHOD ON THE QUALITY AND DRYING CHARACTERISTIC OF MINT LEAVES *(Mentha spicata L.)*

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ABSTRACT
Mint leaves are vegetables used for tea especially in the northern part of Nigerian because of their nutritional and medicinal values. Fresh mint leaves are perishable and to extend their shelf-life drying the leaves is a common practice among the people. The application of a proper drying method is essential to preserve its nutritional and medicinal values. Lack of information on the drying characteristic that could be used for the design of its dryers is a major bottleneck in its processing. This accounts for the poor colour, taste, flavour of dried mint leaves found in the market.In this study, three methods were used to dry mint leaves, sun, oven and shade drying methods. Proximate analyses were carried out on the samples dried with the three methods. Samples drying characteristics were investigated using an oven at 40, 50, 60 and 70 °C. The results show that the drying method significantly affected all the proximate compositions at 5% level. Shade drying has the highest crude protein and ash contents of 7.74% and 8.48% respectively. Carbohydrates were more (30.13%) when open sun drying was employed. Oven drying favoured lowest moisture content of 7.20%, highest crude fiber of 49.34% and highest crude fat contents of 9.22%. To dry mint leaves to equilibrium moisture content, it took 140 min for samples at a drying temperature of 40 °C, 120 min at 50 °C, 90 min at 60 °C and 70 min for 70 °C. Drying of the leaves occurred in a falling rate period.

Keywords: Mint Leaves, Proximate Composition, Drying Rate, Drying Time.

INTRODUCTION

Mint leaves *(Mentha spicata L.*) is a common name for members of the Labiatae (Laminaceae Family). It is a large family of annual or perennial mint leaves and widely grown all over the world for its special mint leaves. The oils of mint leaves are widely used as flavouring in food, cosmetic and pharmaceutical industries. A soothing tea can also be brewed from the leaves. They are used in both fresh and dried forms in different foods. Park *et. al.* (2002) indicated the use of mint leaves in varieties of dishes such as vegetable curries, chutney, fruit salads, vegetable salads, salad dressings, soups, desserts, juices and mint leaves sets. An acceptable instant mint chutney powder was prepared by using shade dried leaves (Satyanarayana *et. al.,* 2001). The mint oil could be extracted either from freshly harvested mint leaves or from semi-dried or dried leaves through a distillation process. The oils contain several compounds and their compounds of essential oils are largely monoterpene and sesquiterpene hydrocarbons and their oxygenated derivatives as well as phenylpropanoids. The chemical composition of mint oils has been studied by different researchers. Studies have shown that carvone is the major component and this is followed by limonene.

Iscan et al. (2002) submitted that the mint oil is use in food, herbal tea preparation and medicinal therapy such as carminative, antispasmodic, antiemetic, anti-inflammatory, diaphoretic, analgesic and stimulant application. It can as well be used in the management of nausea, ulcer, bronchitis, anorexia, sinus, itching, toothache, skin irritation, cold and flu, headache muscle pain, infections caused by bacteria and virus. Its other applications are reduction of stress, mental exhaustion and depression. The mint oil aids in strengthening the immune system and serves as mosquito repellent.

The aim of drying is to reduce the moisture content of the product to a level that prevents deterioration of the product and allows storage in a stable condition. The drying of mint is an effective method that increases the shelf life of the final product. However, drying causes changes in the product mainly associated with fragrance and appearance (Consuelo *et al.*, 2003). Drying of the plant material can be achieved by several processes including hot-air and freeze-drying. Although freeze-drying can be used to avoid damage caused by heat, producing a product with greater physical and chemical qualities but is considered a costly and time-consuming process (Ratti, 2001). Volatile aroma compounds are the most sensitive components in the process of drying. The effect of drying on the component of essential oil of various aromatic plants, fruits and vegetables has been the subject of numerous studies, which show that the changes in the concentration of the volatile compounds during drying depend on several factors, such as drying method and drying conditions (temperature, air, velocity, relative humidity) (Kaya and Aydin, 2009). The effect of a particular drying method on the release or retention of volatile compounds varies and depends on the compound and the spice concerned. Changes in the concentrations of the volatile compounds of mint during drying depend on several factors, such as drying conditions (temperature, air velocity), moisture content, variety and age of the plant, climate, soil, and harvesting method (Asekun *et al.,* 2007; Braga *et al.,* 2009; Rohlloff *et al.*, 2005). Adeyemi *et. al*., (2014) study the influence of drying methods on the proximate and phytochemical composition of *Moringa oleifera*. The highest value for fatty acids, crude fat and ash contents were observed when samples were oven-dried. Garba and Oviosa (2019) investigate the effect of different drying methods on the elemental and nutritional composition of *Vernonia amygdalina* (bitter leaf). Aniebo and Owen (2010) study the effect of age and method of drying on the proximate composition of housefly larvae meal.

Mint leaves (Figure 1) popularly refer to as "*Na' naa*" in the Hausa language is a plant that is takenas tea especially in the northern part of Nigerian because of their nutritional and medicinal values. Fresh leaves of this plant have a very short shelf-life since they are highly perishable. To extend their shelf-life drying the leaves is the best option and a common practice among the people in Africa. They are typically sundried and boiled to make tea.

Figure 1: Mint leaves *(Mentha spicata L.*)

The application of a proper drying method is essential to preserve their vitamin A level, colour, taste, and flavours. The major problems encountered during the processing are the lack of information on the drying characteristic and the drying method of mint leaves that could be used for the design of its dryers. This important information is needed for the effective drying of the products. Presently in the market, the dried mint leaves have poor colour, taste, flavour, and nutritional quality which arises from inefficient drying. These have a connection with the slowness of the drying process, exposure to the environmental contamination, insect and rodent infestation. Therefore, the objectives of the present studies as a part of the efforts towards improving the product were:

i. To determine the effect of drying methods (shade, sun and oven drying) on the proximate properties of mint leaves and
ii. To determine the effect of oven drying temperature (40˚, 50˚, 60˚, and 70˚C) on the drying characteristics of mint leaves.

MATERIALS AND METHOD

Sample preparation

Freshly harvested mint leaves were procured from a farmer in new site Bayero University, Kano State. The leaves were cleaned by removing undesired stems and foreign materials. The leaves were washed and the excess water was removed by draining. The damaged and black leaves were separated manually before subjecting the samples to various drying methods. The experiments were carried out in the Processing Laboratory of the Department of Agricultural and Environmental Engineering at the new site Bayero University, Kano.

Drying methods

Shade Drying: Fresh leaves were spread out uniformly on a clean plat form under a well-ventilated shade which has an average temperature of 30 ± 2 °C. The sample moisture content was then measured every day by the gravimetric method to record the amount of moisture removed until constant weight is attained.

Sun drying: The samples were spread out uniformly on a clean platform under the sun during the daylight from 9 am to 5 pm daily and samples moisture contents were measured at the end of every day to determine the amount of moisture removed. The experiment was carried out until the weight recorded remains constant. The temperature of the environment ranged between 37-41 °C.

Oven Drying: The samples were dried at the standard drying temperatures of 105˚ in a conventional oven (Grook Company in Iran) until their weights remained constant. The oven was equipped with an element to generate heat at a minimum time to reach the desired temperature before each test. The weight monitoring was done by a digital balance (AND, model FX-CT SERIES, FX-300 CT, Japan) in time intervals of 10mins. Triplicate samples obtained after various drying processes were coarsely ground using a domestic mixer grinder. The dried samples were analyzed for quality parameters like moisture content, crude fiber, carbohydrate, crude protein, ash content, and crude fat.

Drying Characteristics

Determination of drying rate

The drying rates of the samples were determined using samples of about 10 g at oven temperature levels of 40, 50, 60, and 70 °C. Weighs of samples were recorded at the initial stage and 10 minutes intervals using a stopwatch. The drying rate of samples was calculated using equation (1).

Drying rate $= \frac{M_{t+dt} - M_t}{dt}$ (Kalaivani *et al* 2013) (1)

Where:

M_t= Moisture content at a time, t.

$M_{(t+dt)}$= Moisture content at time, t + dt (kg water/kg dry matter)

Proximate analysis

Ash content determination

Dried samples (5g) in pre-weighed crucibles were transferred and kept in a muffle furnace at 550°C overnight and left until a light grey ash resulted. The sample was then cooled in a desiccator for 30 min before weighing (Garti *et al.* 2018). The following formula was used to calculate the ash content of the samples.

Ash content % $= \frac{W3 - W1}{W2 - W1} \times 100$ (2)

Where:

W1= Weight of empty crucible

W2= Weight of crucible + samples prior drying

W3= Final weight of crucible + ash

Moisture content determination

Samples moisture contents were determined using A. O. A. C. (1984) oven dried method. The laboratory oven was set at 105°C. About 5g of the leaves were weighed into containers of a known mass. The moisture content was determined using the relation in Equation (3). In addition, dynamic equilibrium moisture contents were calculated using a similar method.

Moisture content $= \frac{\text{mass of sample} - \text{mass of dried sample}}{\text{mass of sample}} \times 100$ (wb) (3)

Estimation of crude fat:

This estimation was performed using the soxhlet apparatus. 20g of each sample was weighed and wrapped with filter paper and placed in a thimble. The thimble was covered with cotton wool and placed in the extraction column that was connected to a condenser. 200ml of n-Hexane was used to extract the lipid (A.O.A.C 1990). The % fat was calculated using equation (4).

% fat $= \frac{W_2 - W_3}{\text{weight of sample}} \times 100$ (4)

Where;

W_2= weight of filter paper and sample before extraction. (g)

W_3= weight of filter paper and sample after extraction. (g)

Determination of crude fiber:

5 g of samples and 200 ml of 1.25% H_2SO_4 were heated for 30 minutes and filtered. The residue was held with distilled water until it was acid-free. 200 ml of 1.25% NaOH was used to boil the residue for 30 minutes; it was filtered and washed several times with distilled water until it was alkaline-free. It was then rinsed once with 10% HCL and twice with ethanol. Finally, it was rinsed with petroleum ether three times. The residue was put in a crucible and dried at 10 °C in an oven overnight. After cooling in a desiccator, it was ignited in a muffle furnace at 550 °C for 90 minutes to obtain the weight of the samples for the determination of the crude fiber (A.O.A.C, 1990). The relation in Equation (5) was used to calculate the crude fiber.

% fiber content = the loss in weight after incineration x 100 (5)

Determination of Crude Protein:

5g of the samples were digested with 5ml of concentrated H_2SO_4 in the presence of Kjeldahl catalysts. The nitrogen from the protein sample was converted to ammonium sulphate that reacted with 2.5ml of 2.5% Brucine reagent 5ml of 98% H_2SO_4 to give a coloured derivative and the absorbance read at 470ml. The percentage of Nitrogen was calculated using Equation (6) and multiplied by 6.25 to obtain the value of the crude protein (A.O.A.C, 1990).

% Nitrogen $= \left(\frac{V_s - V_b \times N_{acids} \times 0.0140}{W} \right)$ x 100 (6)

Where;

V_s = titre value of acid

V_b = titre value of blank

W = weight of sample (g)

Carbohydrate determination

The carbohydrate content of the samples was determined by subtracting the summed up percentage compositions of moisture, protein, lipid, fibre and ash contents from 100 (Garti*et. al.*2018), using Equation (7).

% Carbohydrate = 100 - (%moisture content + %Proteins + %Ash content + %crude fiber + %fat content (7)

RESULTS AND DISCUSSION

Effects of the drying methods on the proximate composition of mint leaves

This section presents the experimental results of the proximate compositions of the mint leaves consisting of moisture content, crude protein, crude fibre, crude fat, ash content and carbohydrate of the mint leaves dried using shade drying, open sun drying and oven drying methods. The results are shown in Table 1. The results showed that the moisture content of the samples ranged from 7.20-11.61%, crude protein 3.59-7.74%, crude fiber 37.89-49.34%, crude fat 5.35-9.22%, ash content 6.60-8.48% and carbohydrates ranged 22.25-30.13%.

Table 1 Proximate composition of dried mint leaves

Replication	Drying Method	Moisture (%)	Crude Protein (%)	Crude Fiber (%)	Crude Fat (%)	Ash (%)	Carbohydrate (%)
1	Shade	11.75	7.70	37.99	5.46	8.76	28.35
2	Shade	11.23	7.21	37.02	5.55	8.67	30.95
3	Shade	11.84	8.31	38.68	5.03	8.01	28.18
Mean values		11.61	7.74	37.89	5.35	8.48	29.16
Standard deviations		0.33	0.55	0.83	0.28	0.41	1.55
1	Open Sun	9.84	7.00	40.12	7.34	6.59	29.87
2	Open Sun	9.62	7.30	39.08	6.81	6.83	30.37
3	Open Sun	8.9	6.91	39.99	7.22	6.39	30.16
Mean values		9.45	7.07	39.73	7.12	6.60	30.13
Standard deviations		0.49	0.21	0.57	0.28	0.22	0.25
1	Oven	7.20	3.50	50.29	9.84	8.33	20.84
2	Oven	7.11	3.76	49.08	8.78	8.29	22.98
3	Oven	7.30	3.53	48.66	9.04	8.54	22.93
Mean values		7.20	3.59	49.34	9.22	8.39	22.25
Standard deviations		0.10	0.14	0.85	0.55	0.13	1.22

From Table 2, the results show that the drying method significantly affected the moisture content, crude protein, crude fiber, crude fat and carbohydrate of mint at 1% level of significance and ash content at 5% level of significance. This implies that the quality of mint leaves depends on the drying method applied. This agreed with the findings of Aniebo and Owen (2010) and Adeyemi *et. al.* (2014). Replication has no significant effect on all the proximate properties of dried mint leaves. This means there is a minimum experimental error for these experiments.

Table 2: ANOVA for the effects of the drying method on the proximate properties of mint leaves.

Proximate Composition	Sources of variation			
	Replication		Drying method	
	F-ratio	Pr > F	F-ratio	Pr > F
Moisture content	2.96^{ns}	0.2525	979.75^{**}	0.0010
Crude protein	0.06^{ns}	0.9399	99.70^{**}	0.0004
Crude fibre	0.51^{ns}	0.6355	2475.67^{**}	<.0001
Crude fat	1.99^{ns}	0.2516	6029.33^{**}	<.0001
Ash	0.45^{ns}	0.6660	16.15^{*}	0.0121
Carbohydrate	2.35^{ns}	0.2116	440.41^{**}	<.0001

Key: ** significant at 1% level, * significant at 5% level, and ^{ns}not significant

Least significant differences (LSD) for mint leaves

The results in Table 2 hitherto show that drying methods significantly affected all the proximate compositions determined. A post-hoc is therefore carried out to ascertain how each of the drying method affects the proximate values of the mint leaves. The result of LSD is presented in Table 3. The result shows that the moisture content of mint leaves dried under the shade has the highest value followed by the leaves dried under the sun while oven dried leaves have the lowest moisture content. Similar results were obtained for bitter leaves (Garba and Oviosa, 2019). The trend of the results observed may be as a result of the energy available for drying in each of the drying methods. Higher energy is available in the oven than the open sun drying and the shade drying, hence the leaves in the oven lose more water. It is important to note that the mint leaves with the lower moisture content will likely have a longer shelf life as there is a low tendency of microbial attack on the product. Crude protein in mint leaves is higher when dried in the shade and the value is statistically at par with the crude protein in the sun dried leaves, but the crude protein is lower when dried in the oven. The higher heat energy in the oven might have caused the depletion in the protein content of the sample dried in the oven. It is evident that the crude fat for the mint leaves dried using the three drying methods are statistically different. Oven dried mint leaves have the highest crude fat, this is followed by sun dried mint leaves, while the shade dried mint is the lowest in crude fat.

Crude fiber in mint leaves is higher in the oven dried leaves than those that are sun dried and shade dried. The crude fiber in the sun dried and shade dried are not statistically different. The result of crude fiber does not conform with the findings on bitter by Garba and Oviosa (2019). The result of ash content shows that shade drying has the highest value and it is statistically at par with the oven drying, while ash content of sun drying is the lowest. This shows that more minerals are depleted from the sun dried samples, but shade and oven dried samples retained more minerals of the mint leaves. Carbohydrates in the sun dried leaves have the highest value, this is statistically at par with the carbohydrates in the shade dried samples and the oven dried sample is the least in carbohydrates. This result corroborates with the findings on *Hibiscus cannabinus* leaves (Garti *et al*., 2018).

Table 3 LSD for Mint Leaves

Drying method	Moisture content	Crude protein	Crude fat	Crude fibre	Ash	Carbohydrates
Shade	11.607[a]	7.740[a]	5.347[c]	37.897[b]	8.480[a]	29.160[a]
Sun	9.453[b]	7.070[a]	7.123[b]	39.730[b]	6.603[b]	30.133[a]
Oven	7.203[c]	3.597[b]	9.220[a]	49.343[a]	8.387[a]	22.250[b]

Drying characteristic of mint leaves

i. Variation of moisture content with the drying time of mint leaves

The variation in the moisture content of mint leaves as a function of drying time at different temperature levels is presented in Figure 2. The results show that mint leaves have an initial moisture content of 82.5% d.b and the moisture content of samples was found to decrease with the increase in drying time and drying temperature. This is because the water in the samples attained more energy to go out of the sample at a higher temperature. The rate of moisture loss was higher at a higher temperature than low temperature and then total drying time reduced substantially with the increase in temperature. Similar results were observed for *Baobab (Adansonia digitata L.)* leaves (Shittu and Timothy, 2020). The curve can be applied in the determination of the time required to dry mint leaves to given moisture content at a prescribed temperature. It can be read from the curve that to dry mint leaves to equilibrium moisture content, it took 140 min for samples at a drying temperature of 40 °C, 120 min at 50 °C, 90 min at 60 °C and 70 min for 70 °C.

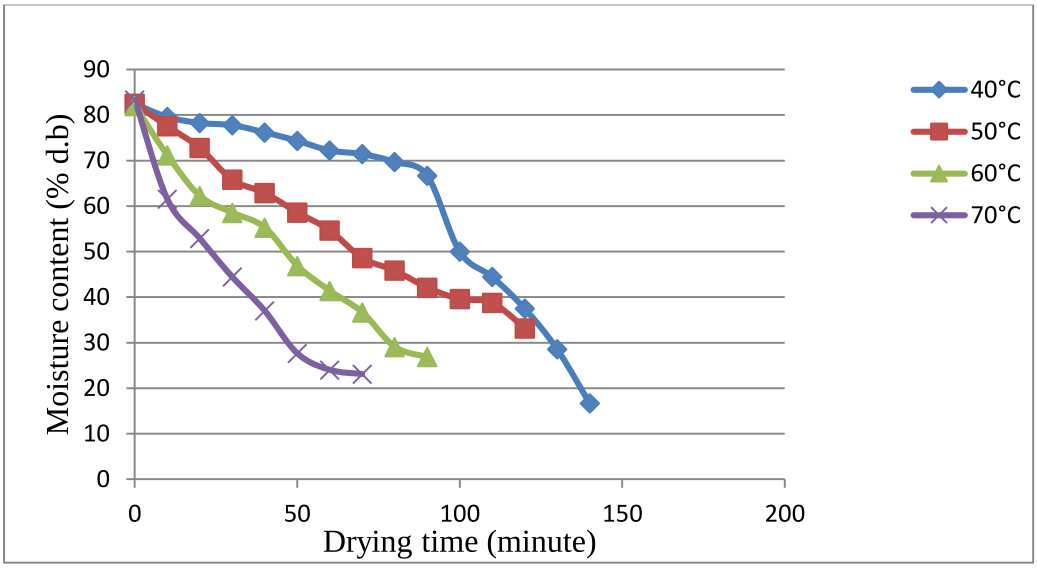

Figure 2: Graph of moisture content against drying time

ii. Variation of drying rate with drying time

The variation in the drying rate of mint leaves over drying time at different temperature levels is presented in Figure 3. The results show that the drying rates for the leaves decrease with the increase in the drying time and the drying rate increases with the increase in the temperature. This conforms with the behaviour of several biological materials reported (Lad *et. al*., (2019), Shalini *et al*., (2017), Deshmukh *et al*., (2014)). The results also show that the drying of the leaves occurred in the falling rate period and no constant rate period was observed. Drying in the falling rate period indicates that, internal mass transfer of moisture has occurred by diffusion therefore, there was no free water in the leaves to dry at a constant rate.

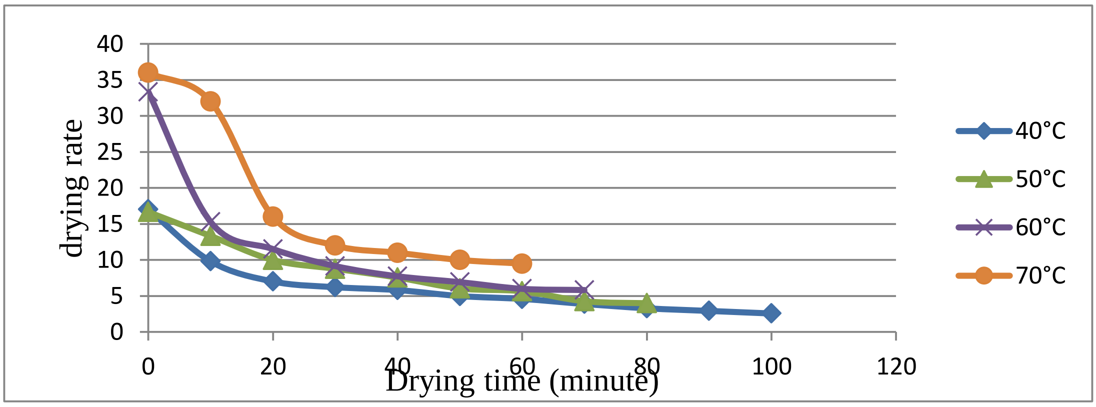

Figure 3: Graph of drying rate against drying time

CONCLUSION

In the present study, the effect of the different drying methods on the proximate composition of mint leaves was established. The study revealed that shade drying favoured crude protein and ash contents of the mint leaves. Carbohydrates were more when open sun drying was employed. Oven drying supports moisture content, crude fiber and crude fat contents of the mint leaves. The drying characteristics of mint leaves were carried out using the oven at drying air temperature of 40°C, 50°C, 60°C and 70°C. Mint leaves have an initial moisture content of 82.5% d.b and the moisture content of samples was found to decrease with the increase in drying time and drying temperature. The drying of the mint leaves occurred in the falling rate period and no constant rate period was observed which shows an internal mass transfer of moisture occurred by diffusion.

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