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# Kinetics of Moisture Loss during Dehydration of Drum Stick Leaves (Moringa Oliefera) In a Bio-Mass Tray Dryer

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***Abstract:*** ***Studies were conducted on a newly developed bio-mass dryer installed with wire mesh tray with natural convection. Drum stick leaves were dehydrated using agri-waste as fuel for the dryer. Agriculture fields generate lot of waste in the form of fodder, leaves, sticks and roots, etc, It has been a major problem of pollution when farmers put these waste materials on to fire. The dryer is made of bricks to suit the drying temperatures of foods. Dryer is designed to generate temperature of the order of 50 – 100 deg C to suit the heat requirements of most of the vegetables, especially for green leafy vegetables. This paper reports the data collected during the dehydration of drum stick leaves and data analyses on kinetics of moisture changes. Nutritional values are measured and reported. Data of moisture loss is modeled using exponential and polynomial equations. The highest R square values are obtained with polynomial kinetic model. The moisture rate is maintained below the standard value in all the experimentation.***

**Key words: Drum stick leaves, bio-mass dryer, moisture loss, modeling, rate constants**

## I. INTRODUCTION:

Food dehydration technique has been used since unknown time to preserve food items like fruits, vegetables and grains. Sun drying is the cheapest drying method. However food hygiene during handling is the question. Modern methods are available using tray dryers with heating source of electrical heaters, steam or gas fired. Use of waste material from the agriculture fields, as a heating medium for the dehydration is a new concept employed in the current research work.

The storage life of food items increase with reduction in moisture content in the food(Fenemma et al.1986). Use of different dehydration equipment like tray dryers, vacuum dryers ( Jayaraman and DasGupta 1995),

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Fluidized bed drying (Mujumdar, A. S., & Devahastin, S. 2000) spray dryers (Ramesh Babu D and DasGupta DK,2005) are very popular in industrially developed areas or urban areas. These dryers are equipped with electrical/ steam heating system for heating the air inside the dryer. Extensive studies are carried out by various researchers using these dryers.

However these equipment are expensive and not used in rural areas due various practical limitations like, non availability of electrical power, expensive operation of equipment, lack of skills to operate and maintain etc., Rural areas are surplus with agricultural and biomass waste like straw, fodder, leftover dry material after harvesting from the fields. These materials can be used as fuel for heat generation for drying purpose. Biomass dryers are one good solution to utilize all agricultural waste materials for heating purpose to dry the food materials. Bio mass dryer with natural convection is simple and doesn't need any electrical or other means for heat generation. This will be beneficial for rural people to make value added products by dehydrating green leafy vegetables or fruit and vegetables. Given a proper sized, low-cost dryer, food processing can proceed uninterrupted in rural areas (K.J. Chua and S.K. Chou 2003).

Subadra et al (2007) reported the nutritional properties of drumstick leaves and benefits during usage in the Indian diet. Premavalli et al2001, studied the color and nutrient properties of green leafy vegetables in detail and reported the benefits. Gupta S et al 2005 reported the nutrients and anti nutrient of green leafy vegetables.

**The major benefits of these natural convection biomass dryers are**

1. Surplus agri/biomass waste is utilized for drying of green leafy vegetables/vegetables locally grown.
2. Creating wealth for rural people by value addition to the green leafy vegetables by drying. Other benefits are easy operation and low processing cost.
3. No electricity/ gas are required. So very much suitable for rural places which are not connected with electricity or gas delivery

Several studies are done by various research using industrial dryers and solar dryers. Limited research is available in the literature regarding biomass dryers and especially dehydration of green leafy vegetables.

Drum stick leaves are widely used as an ingredient for food preparation in India and other places, also used as medicinal especially ayurvedic preparations.

**The objects of this study are**

1. Dehydration of green leafy vegetables, specifically the drum stick leaves
2. Standardize the temperature and time for dehydration of drum stick leaves
3. Develop a dried product from the drum stick leaves in packed form.

**Materials and Methods:**

**Biomass dryer:** It is designed and constructed at the premises of S R Engineerng college, Warangal, Telangana is used for this study. The dryer contains four trays designed with perforations for heat transfer by natural convection. The outer chamber is made of hollow bricks which are suitable to withstand firing temperatures of the order of 200 to 350 deg C.

**Moisture measurement:**

The leaves are taken out at an interval of 10 minutes for the purpose of moisture measurements. The samples removed from the dryer are weighed first and then transferred to a hot air oven to finally remove all the moisture. This process is doneas per the methods given by (Ranganna, 1986). The weight of the sample is recorded and difference of weights gives the moisture present in the sample.

A precision weighing scale ( Mettler,USA ) is used with petri plates to take the moisture measurements with respect to time. Temperature is measured with a thermometer connected to the bio-mass dryer.

Nutritional properties of the dried leaves were tested by a testing laboratory of M/s Firstsource laboratory solutions LLP,Hyderabad. The moisture test was conducted as per the procedure of international standard of AOAC 20$^{th}$ edition 925.09 and expressed in g/100g. Ash content was measured as per AOAC 20$^{th}$ edition 923.03 and expressed in g/100g. Fat in g/100g is calculated as per AOAC 20$^{th}$ edition 922.06. Protein was measured as per IS7219:1973 and expressed in g/100g. Carbohydrates and energy was calculated as per standard calculation and expressed in g/100gm and Kcal/100g respectively.

**Construction of Drying chamber:**

**Fig 1: Samples of hollow bricks used for construction of biomass dryer firing chamber**

**Fig2: Preparation of drum stick leaves loaded on to perforated trays for drying**

**Figure 3: Conducting moisture drying experiment in a hot air oven till equilibrium.**

**Fig 4: Dried drumstick leaves packed in 120 gauge polyethylene pouch**

**Flow Chart of drying process**

**Collecting leaves form drum stick plant**
↓
**Washing the leaves using Chlorine water**
↓
**Separating leaves from the stem**
↓
**Surface drying the leaves in open air**

**Preparing the bio mass dryer**
↓
**Firing the bio mass**
↓
**Setting the temperature**
↓
**Monitoring to get required temp.**

↓
**Spreading the leaves on the trays**
↓
**Transferring the trays into the dryer**
↓
**Monitoring the drying process**
↓
**After complete drying, remove dried leaves from the trays**
↓
**Pack the dried leaves in polythene packaging**
↓
**Store in a cool place.**

## Results and discussion:

**Table 1 : Nutritional properties of drum stick leaves:**

| **Temperature degree Centigrade** | **Moisture g/100gm** | **Ash g/100gm** | **Fat g/100gm** | **Protein g/100gm** | **Carbohydrates g/100gm** | **Energy** K cal/gm |
|---|---|---|---|---|---|---|
| **60** | **5.33** | **11.12** | **5.74** | **28.21** | **49.60** | **362.89** |
| **70** | **5.40** | **11.48** | **2.67** | **24.13** | **56.32** | **345.83** |
| **80** | **4.93** | **11.42** | **2.59** | **23.80** | **57.26** | **347.58** |

The nutritional properties indicate 4.93 to 5.4% moisture, 11.12 to 11.48% of ash, 2.67 to 5.74% of fat, 23.8 to 28.2% of protein, 49.6 to 57.26% and energy of 345.83 to 362.89Kcal/gm. Being dried product the nutritional condensation and richness is observed. Consumption of dried leaves will definitely make nutria-rich product. A good indication can be seen from the ash content indicating the mineral content and richness. Slight variations in the values amount temperatures may be due to relative changes in other components and moisture content.

**Table 2: Measurement of moisture loss of leaves with respect to different temperatures and feeding wood for burning.**

| S.No | Before drying weight of product in grams | After drying weight of product in grams | Weight loss in grams | Temperature in degree Centigrade | Moisture in percentage | Time in minutes | Wood burning in the firing chamber in Kgs |
|---|---|---|---|---|---|---|---|
| 1 | 35 | 35 | 0 | 29 | 75 | 0 | 0 |
| 2 | 35 | 27.5 | 7.5 | 35 | 57.6 | 30 | 3 |
| 3 | 35 | 23.07 | 11.93 | 45 | 48.6 | 60 | 6 |
| 4 | 35 | 15.38 | 19.62 | 50 | 19.2 | 90 | 8 |
| 5 | 35 | 13.84 | 21.16 | 60 | 7.2 | 120 | 9 |
| 6 | 35 | 12.59 | 22.41 | 65 | 5.8 | 150 | 11 |
| 7 | 35 | 11.36 | 23.64 | 70 | 4.6 | 180 | 12 |
| 8 | 35 | 11.1 | 23.9 | 75 | 4.2 | 210 | 12 |
| 9 | 35 | 10.28 | 24.72 | 80 | 3.4 | 240 | 13 |

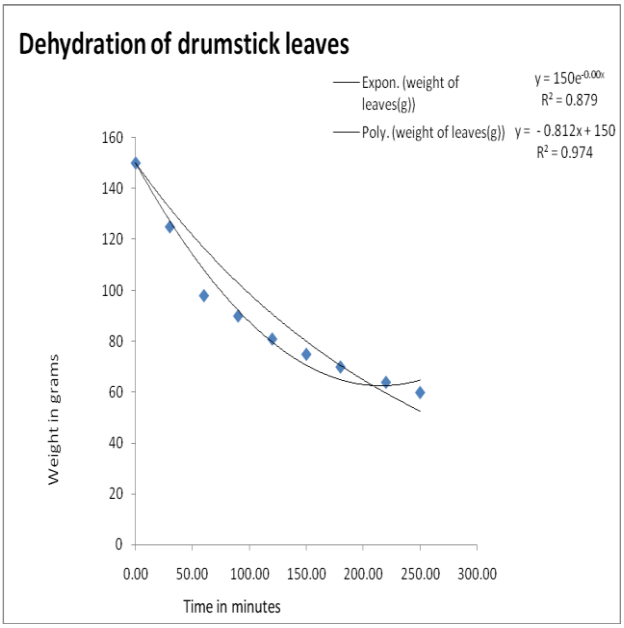


Figure 6: Mathematical kinetic model from Rate of moisture loss curve( Weight loss of leaves with respect to time)

Rate constants are calculated from the drying phenomenon data with respect to time. Average temperature of 55degC has been maintained near the trays, during drying kinetics experiment. Polynomial model found better fit with 0.974 as goodness of fit.

The data is fitted to two mathematical kinetic models viz the exponential model and polynomial model. Exponential model fitted with $r^2$ value of 0.879, and Polynomial second order model fitted with kinetic equation given in figure 6 with $r^2$ value of 0.974.

From over all experimental results it can be concluded that dehydration of uncommon product "drumstick leaves in dried form" can be successfully made with the protocols made from this study at various temperatures. Nutritional results indicated good nutritional properties of the dried product. The results indicated good and safe moisture content achieved after drying which is fit for long term preservation in poly ethylene packaging without growth of moulds and micro-organisms. Mathematical model for kinetics of moisture loss indicated the polynomial model with best fit. Further work be carried to study the shelf life properties , changes of product in packaged form for long term and other products can be dried in this bio mass dryer.

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