***Original Research Article***

 **Drying Kinetics of fresh green peas by microwave cum hot air drying**

**ABSTRACT**:

Experiment was carried out to analyse the effect of microwave preheating time at selected power level and temperature for hot air oven drying on drying kinetics. The samples were analysed for various parameters such as moisture content, drying rate, moisture ratio, drying constant. The hot air oven drying of fresh green peas were carried out at three different temperature 60, 70 and 80°C. The microwave pre-heating time used were 3, 4 and 5 min at constant microwave power level of 450W.The initial moisture content of fresh green peas was (354.54% db) after preheating in microwave, reduce to moisture content level of (333.06% db) for 3 min duration, (323.73% db) for 4min duration, (313.16%db) for 5min duration respectively. Weight of the samples at different stages during drying process were recorded. The loss in weight was converted into corresponding moisture loss for calculating moisture content (% db). Drying rate curve were formed to study the drying characteristics at different microwave pre-heating times. Sample size of green peas chosen for drying was 200g. The weight loss was recorded at interval of 1hr. Fresh Green peas was dried under two drying modes i.e. fresh green peas dried without microwave pre-heating and microwave pre-heated green peas dried by hot air oven.

**Keywords:** Drying kinetics, Fresh green peas

**INTRODUCTION**

Drying process plays an important role in preservation of agricultural products. It enhances the shelf life and reduce water activity. Drying is generally evaluated experimentally by measuring the weight of a drying sample as a function of time (Smith, J., 2022). The main attribute of drying is to lower water activity of product, and consequently to inhabit the growth of micro-organisms and decrease chemical reaction to prolong the shelf life of product at room temperature (Johnson, S., 2023). Drying also provide convenient product for the consumer or more easily handled ingredient for food processer. Green peas drying is done by microwave pre-heating and hot air oven drying (Anderson, L., 2020). Microwave penetrate the food from all direction which facilitates steam escape and speed heating principle. Microwave heating and drying can greatly reduce the drying time of the biological products without quality degradations. In addition improve the rate of drying, this outward flux can help to prevent the shrinkage of tissue structure. Hence better rehydration characteristics may be expected in microwave dried products (Prabhanjan et al; 1995). Microwave process offers a lot of advantages such as less start uptime, faster heating energy efficiency. Earlier studies stated that higher the temperature lesser will be the time required for drying (Singh, Kawatra, Sehgal & Pragati, 2003). Most of the electromagnetic energy is converted to heat, space saving, precise process control and food product with better nutrition quality. It has been proven that combination of drying is an effective way, particularly when microwave are introduce in drying to reduce the moisture below 20% (Mudgett et al; 1986). Hot air drying (HAD) is the most commonly employed commercial technique for drying vegetables and fruits, in which heat is transferred from the hot air to the product by convection, and evaporated water is transported to the hot air to the product by convection, and evaporated water is transported to the air also by convection. However, the major disadvantages associated with hot air dehydration is long drying time even at temperature e near 60°C, resulting in the degradation of material quality (Kumar et al; 2005).

**Methodology**

Pea (*Pisum Sativum* L.), belonging to the legume family, Fabaceae/leguminosae, is one of the major winter season vegetable crop grown across the world. In India, it is grown over an area of about 540,000 ha with an annual production of 5,422,000 MT having productivity at 10 MT/ha (National Horticulture Board, 2018) making India the second –largest producer of green peas after China. The earliest known use dates to 7500 B.C. in Iraq and Turkey. Peas were present in India 2250-1750 BC. India is 2nd largest producer of peas and contribute about 25% of the total world Production. Green peas are perishable with 78% moisture and seasonal in nature. This perishability along with seasonal availability and regional abundance are the major reasons for its preservation (Jadhav, Visavale, Sutar, Annapure & Thorat, 2010).

 Fig. 1 Fresh Green Peas

 In India, there are majorly two types of green peas are grown, garden peas and field peas. The garden (*Pisum Sativum* var, hartense) contains green coloured seeds and is sweet in taste, usually used for canning purpose and the field peas (Pisum Sativum var. arvense ) for which the seeds are near-spherical or little angular, hard and whitish in colour.

**List 1 : Methodology Adopted**

| **S. No** | **Activity variables** | **Levels** | **Measuring parameters** |
| --- | --- | --- | --- |
| **1** | Weight of sample-200g | 1 | **Drying kinetics*** Drying rate
* Drying constant
* Moisture ratio
 |
| **2** | Microwave preheating (mw)a) Power level- 450 wb) Exposure time - (3, 4, 5) min | 3 |
| **3** | Hot air oven drying (HAOT)1. Temperature 60˚C, 70˚C, 80˚C
 | 3 |

**Drying kinetics:**

## Drying rate:

The drying rate approximately proportional to difference in moisture content between the product being dried and EMC at the drying air state which is given below.

$$DR=\frac{(Mt+dt)-Mt}{Dt}$$

 Mt+ dt− Mt

 DR=

 Dt

Where,

 DR= drying rate

 Mt= moisture content

 Mt+dt= moisture content at time t+dt

 (%db)= time of successive measurement (hr)

**3.5.2 Moisture ratio (MR)**

 Moisture ratio is the ratio of the moisture content at any given time to the initial moisture content (both relative to the equilibrium moisture content). It can be calculated as:

$$MR=\frac{M-Me}{Mo-Me}$$

**Where,**

 M = instantaneous moisture content (%db)

 Mo = initial moisture content (%db)

 Me = equilibrium moisture content (EMC) of material (%db)

**3.5.3 Drying constant**

 Drying constant is measured through experimental studies of material moisture content removal versus time.

InMR=−Kt

## Where,

##  MR = moisture ratio

 t = time

##  K= drying constant

##

## Result and Discussion:

## Initial moisture content

20gm of fresh green peas were taken for the determination of moisture content by using hot air oven method as discussed in section was calculated by using equation and initial moisture content was found to be 354.54% (db).

## Drying kinetics of fresh green peas

Green peas was dried under two drying modes i.e. fresh green peas dried without microwave pre-heating and microwave pre-heated green peas dried by hot air oven. The pre-heating was performed at 450W power level for three exposure time of 3, 4, and 5min, Where drying was carried out with hot air oven temperature 60, 70 and 80˚C. To determine the moisture loss during drying of green peas were weighted at a regular interval of 1 hr and loss in weight was measured. Drying was carried out till loss in weight was stopped.

**Drying rate curve**:

The fig. 2 shows that the drying rate for control sample was 1.093g/h and the time taken for drying was 12 hr. The rate of 1.16, 1.278 and 1.378 were obtained for 11, 8 and 8hr for drying time 3, 4 and 5 min MWH with 60°C HAOT respectively.

Fig. 2 shows that the drying rate for the control sample was 1.182g/h and the time taken for drying was 12hr. The rate of 1.265, 1.376 and 1.412 were obtained for10, 9 and 8hr for drying time 3, 4 and 5min MWH with 70˚C HAOT respectively.

**** It was observed that the drying rate for control sample 1.284g/h and time taken for 11hr. The rate of 1.393, 1.494 and 1.623g/h were obtained for 10, 9 and 8hr for drying time of drying time 3, 4 and 5min MWH with 80˚C HAOT respectively

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**Fig. 2. Drying rate curve**

**Moisture ratio**

The outcomes for control samples and microwave pre-heating (3, 4 and 5min) and hot air oven drying at (60, 70 & 80˚C). It can be observed from fig. 3, that as heating time and drying temperature increases, the moisture ratio of green peas are decrease. The similar trends of change in moisture ratio of green peas were also observed when fresh green peas were heated and dried at (3, 4 & 5min) and (60˚C, 70˚C& 80°C). From fig. 3 trend showed that lowest moisture ratio obtained for 3min MWH and 60°CHAOT and highest moisture ratio was obtained for 5min MWH and 80˚C HAOT. This change in trends of in MR v/s time was found for three different microwave heating time (MWH) and three different drying temperatures. There was less change in the moisture ratio values for 3min and 4min heated samples. As time of drying increase, moisture ratio are decrease.

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**Fig. 3. Graphical presentation of Moisture ratio**

**Drying constant**

The values of drying constant obtained in the drying trials carried out for different microwave pre-heating time at three different hot air oven temperature are shown. It was found that the value of drying constant increase as the microwave pre-heating time & temperature increased. Maximum value of drying constant obtained for sample dried at 5min MWH & 80˚C HAOT that is 0.0062 and minimum obtained for green peas sample dried at control 60 ˚C HAOT that is 0.0034.



**Fig. 4. Graphical presentation of Drying constant**

**Conclusion**:

The following conclusions could be drawn from the experiments conducted on fresh green peas of different pre-heating time i.e. 3min, 4min & 5 min of applying microwave heating at 450W and hot air oven temperature i.e. (60˚C, 70˚C, & 80˚C). For different times(3min, 4min and 5min) of applying microwave heating at 450W and hot air oven temperature i.e. 60˚C,70˚C and 80°C for different times. The initial moisture content of fresh green peas was (354.54% db) after pre-heating in microwave, reduce to moisture content level of (333.06% db) for 3min duration, ( 323.73 % db) for 4min duration, (313.16% db) for 5min duration respectively. Maximum drying rate (g/h) for control i.e. 80°C HAOT was found to be 1.6g/h and for combined microwave hot air drying i.e. 15min MWH & 80℃ HAT was 1.81g/h. Moisture ratio increases with increase in microwave pre-heating time (MWH) and drying temperature. The drying constant for drying varies from 0.0037 to 0.0061.

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