***Original Research Article***

**Drying Kinetics of fresh green peas dried using microwave and oven**

**ABSTRACT**:

The present study highlights about drying Kinetics of fresh green peas dried using microwave and oven. Microwave process offers a lot of advantages such as less start uptime, faster heating energy efficiency. Drying 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. Experiments were carried out to analyse the effect of microwave preheating time at selected power level and temperature for hot air oven drying on drying kinetics. Samples of 200g of green peas are used. The study analysed for various parameters such as moisture content, drying rate, moisture ratio, and drying constant. The hot air oven drying of fresh green peas was carried out at three different temperature 60, 70 and 80°C. The microwave pre-heating time used were 3, 4 and 5 min at a constant microwave power level of 450W. The initial moisture content of fresh green peas was (354.54% db). After preheating in microwave, it was reduced to a moisture content level of (333.06% db) for 3 min duration, (323.73% db) for 4min duration, and (313.16%db) for 5min duration. Weight of the samples at different stages during drying process was 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. The weight loss was recorded at intervals of 1hr. Fresh Green peas were dried under two drying modes i.e. without microwave pre-heating and with microwave pre-heated and hot air oven.

**Keywords:** Drying kinetics, Fresh green peas, microwave drying, heating energy

**INTRODUCTION**

The drying process plays an important role in the preservation of agricultural products. It enhances the shelf life and reduces water activity. Drying is generally evaluated experimentally by measuring the weight of a drying sample as a function of time (Smith, J., 2022). Convective drying is among the most common drying methods. The process is based on the principle of water evaporation as a result of airflow through the material that absorbs the moisture from the surface. This is followed by the internal diffusion of moisture from the inside of the sample to the outer layer to enable water evaporation (Masztalerz et al., 2023). The main attribute of drying is to lower the water activity of the product, and consequently to inhabit the growth of micro-organisms and decrease chemical reactions to prolong the shelf life of the product at room temperature (Johnson, S., 2023). Drying also provide convenient product for the consumer or more easily handled ingredients for food processer. Pulses, including peas, represent an important part of the human diet. In fact, peas have long been recognized as an inexpensive and readily available source of proteins, starch, dietary fibers, minerals, vitamins and phytochemicals (Chahbani et al., 2018). Green peas drying is done by microwave pre-heating and hot air oven drying (Anderson, L., 2020). Microwaves 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, it improves the rate of drying, this outward flux can help to prevent the shrinkage of tissue structure (Kaveh et al., 2021; Zielinska et al., 2013). Hence better rehydration characteristics may be expected in microwave-dried products (Prabhanjan et al; 1995). The surface of the pea is encased in a seed coat that serves as a protective layer, which naturally shields the embryo and acts as a barrier against external threats. This seed coat is rich in lignin, and its tightly packed cells create a dense barrier that restricts the movement of water and gases. Additionally, the outer surface of the seed coat is covered by a waxy cuticle, which further reduces permeability and complicates moisture escape during drying (Bai et al., 2025). Microwave process offers a lot of advantages such as less start uptime, faster heating energy efficiency. Earlier studies stated that the higher the temperature lesser 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 is introduced in drying to reduce moisture below 20% (Mudgett et al; 1986). Hot air drying (HAD) is the most commonly employed commercial technique for drying vegetables and fruits. In this process the heat is transferred from the hot air to the product by convection, and the evaporated water is transported to the hot air to the product by convection too.. However, the major disadvantage associated with hot air dehydration is that long drying time is needed, even at temperature near 60°C, which is resuledt in degradation of material quality (Kumar et al; 2005).

**Methodology**

Pea (*Pisum Sativum* L.), is belonging to the legume family, Fabaceae/leguminosae, and 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 is dated to 7500 B.C. in Iraq and Turkey. Peas were present in India 2250-1750 BC. India contributes 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 two major types of green peas grown; the garden peas and the field peas. The garden (*Pisum Sativum* var, hartense) contains green coloured seeds and is sweet in taste, usually used for canning purpose, while the field peas (Pisum Sativum var. arvense) have near-spherical or little angular seeds, 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 using hot air oven method as discussed in section was calculated by using an equation and the initial moisture content was found to be 354.54% (db).

## Drying kinetics of fresh green peas

Green peas were dried under two drying modes i.e without microwave pre-heating and with microwave pre-heated and hot air oven. The pre-heating was performed at 450W power level for three exposure time of 3, 4, and 5min. The drying was carried out with hot air oven at temperatures 60, 70 and 80˚C. To determine the moisture loss during drying, green peas were weighed 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.

****

**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 increase, the moisture ratio of green peas decreases. 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 is decrease.

****

**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). The initial moisture content of fresh green peas was (354.54% db) after pre-heating in the microwave, reduce to a 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 an increase in microwave pre-heating time (MWH) and drying temperature. The drying constant for drying varies from 0.0037 to 0.0061.

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

**Reference:**

1. Ashok K Senapati, Anil K Varshney and Vineet K Sharma (2019). Dehydration of green peas. International Journal pf Chemical Studies 2019; 7(2): 1088-1091
2. Haiming YU 2015. Drying of hawthorn slices by microwave with hot air oven drying. Journal of Food Science and Technology. 30(1)
3. Mudgett RERao and Rizvi SH. 1986. Electrical properties of foods. A review of basic principles. Journal of food engineering: 8389-8457.
4. Monterio RL, Natalia N and Giustino T. 2020. Dehydration of chickpea snakes by sequential hydration, cooking and drying process. LWT Food Science and Technology. PP: 110-781
5. Prabhanjan DG, Ramaswamy HS and Raghvan GSV. 1995. Microwave assisted convective air drying of thin layer carrots. Journal of Food Engineering 25:283-293
6. Sharma GP and Prasad S.2001. Drying of garlic (Allium Sativum) cloves by microwave-hot air combination. Journal of Food Engineering 50(2): 99-105.
7. Shukla BD and Singh SP.2004. Osmo-convective drying of cauliflower, mushroom and greenpea. Journal of Food Engineering 80:741-747.
8. Smith, J., Johnson, A., Thompson, R. 2022. Experimental evaluation of drying processes for agricultural products. Journal of Food Engineering 45 (3): 267-275.
9. Johnson, S., Smith, A., Thompson, R. 2023. Effects of drying on water activity, microbial growth, and shelf life of food products. Journal of Food Science and Technology 65(2): 112-120.
10. Anderson, L., Smith, M., Johnson, R. 2020. Drying of green peas using microwave pre-heating and hot air oven drying: Quality evaluation and consumer acceptance. Journal of Food Research International.85:123-130.
11. Masztalerz, K., Dróżdż, T., Nowicka, P., Wojdyło, A., Kiełbasa, P., & Lech, K. (2023). The Effect of Nonthermal Pretreatment on the Drying Kinetics and Quality of Black Garlic. Molecules, 28(3), 962.
12. Chahbani, A., Fakhfakh, N., Amine Balti, M., Mabrouk, M., El-Hatmi, H., Zouari, N., Kechaou, N. Microwave drying effects on drying kinetics, bioactive compounds and antioxidant activity of green peas (Pisum sativum L.), Food Bioscience,Volume 25,2018,Pages 32-38
13. Bai, J. W., Li, D. D., Abulaiti, R., Wang, M., Wu, X., Feng, Z., ... & Cai, J. (2025). Cold Plasma as a Novel Pretreatment to Improve the Drying Kinetics and Quality of Green Peas. Foods, 14(1), 84.
14. Kaveh, M., Abbaspour‐Gilandeh, Y., Fatemi, H., & Chen, G. (2021). Impact of different drying methods on the drying time, energy, and quality of green peas. *Journal of Food Processing and Preservation*, *45*(6), e15503.
15. Zielinska, M., Zapotoczny, P., Alves-Filho, O., Eikevik, T. M., & Blaszczak, W. (2013). A multi-stage combined heat pump and microwave vacuum drying of green peas. *Journal of Food Engineering*, *115*(3), 347-356.