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Comparative study of tray dryer, infrared dryer and hot air oven for drying of chickpeas

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Abstract
Chickpea, a type of pulse that is are of two varieties Desi and Kabul. The production of chickpeas is limited since they are seasonal in nature. Hence it is important to preserve the chickpeas in order to make them available throughout the year. Sun drying, the most common method of drying of chickpeas has several disadvantages with respect to the quality of the product and it is also time consuming. The study is done to find out the best possible alternative methods in terms of better quality and efficiency among three methods of drying- infrared, hot air oven and tray drying. Drying was carried out at 60˚C and 80˚C and the values were recorded in an interval of 20 minutes. Results revealed that infrared drying is better among the three and tray drying is better when compared to hot air oven method. The time taken for drying in hot air oven is twice the time of tray dryer. The rate of drying also predicts the same. Thus, it can be concluded that infrared method of drying is better in terms of efficiency and quality among the other methods.

Keywords: chickpea, (*Cicer arietinum*), tray dryer, infrared dryer, hot air oven

1. Introduction
Chickpea, (*Cicer arietinum*) also known as channa dal, is a type of pulse, with one seedpod containing two or three peas. There are two main kinds of chickpeas: Desi, which has small, darker seeds and a rough coat, cultivated mostly in the Indian subcontinent, Ethiopia, Mexico, and Iran; and Kabuli, which has lighter coloured, larger seeds and a smoother coat, mainly grown in Southern Europe, Northern Africa, Afghanistan, Pakistan, Chile, and India (Lopez *et al.* 2014) [7]. The availability of chickpeas is limited only to some part of the year since it is seasonal which creates the need for its preservation (Sharma and Garg, 2014) [11].
The technique of drying is probably the oldest method of food preservation practiced by Human. The main aim of drying of foods is to reduce the moisture which helps in extending the shelf life (Antal, 2015) [1]. The main reason to remove moisture is to prevent or inhibit microorganisms and hence preserve the foods and to reduce the weight and bulk of food for cheaper transport and storage. (Mayor and Serena, 2004) [8]. Achieving the desired dehydration by reducing energy consumption without substantial loss of colour, appearance, flavour, taste and chemical components is one of the main challenges (Antal, 2015) [1]. Open-air drying is the most commonly used method in the tropical and subtropical countries. However, it has large number of disadvantages especially with respect to product damage mainly due to inefficient or ununiform drying (Mujumdar, 2007) [10]. Open-air drying, one of the common methods for drying of chickpea, takes 15 to 20 days in summer time to attain complete drying of the product. Thus, it becomes essential to look for alternative drying processes, like tray dryer, infra-red dryer, hot air oven for improving product quality along with saving time (Lopez *et al.* 2014) [7].
Drying is energy-intensive and has a negative environmental impact due to fact that most of the thermal energy needed is obtained by combusting fossil fuels (Lopez *et al.* 2014) [7]. The demand for energy for drying will increase with prosper of global economies. Thus, it is important to understand the operations well and to ensure that it is carried out as efficiently as possible within the economic constraints of the market.
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 means of convection, and evaporated water is also transported to the air by convection (Lewicki, 1998) [6]. However, the major disadvantage associated with hot air dehydrating is the prolonged drying time even at temperatures near 60°C, resulting in the degradation of material quality (Kumar *et al*., 2005).
Infrared (IR) drying is based on the action of IR wavelength radiation from heat source, which interacts with the internal structure of the sample and thus increases the temperature and favours the evaporation of moisture (Celma *et al*. 2008) [3]. While drying, the infrared rays penetrate the wet sample to a certain depth and help in increasing their temperature without heating the surrounding air. Then, the diffusion rate of the water through the material increases and consequently the radiation properties of the samples are changed due to decreasing moisture content, which diffused out of the materials into the air (Laohavanich & Seree, 2008) [5]. IR drying is gaining popularity in food processing because of its inherent advantages over hot air drying. IR drying has several advantages including uniform heating, high heat transfer rate, reduced processing time and energy uptake and improved product quality (Sandu, 1986; Vishwanathan *et al*., 2013) [14].
In this work, the drying of chickpea, using tray dryer, infra-red dryer, hot air oven at 60ºC and 80 ºC was carried out. This work was done to find out the best possible method and the suitable temperature of drying and also to find out the cost effective and energy efficient process for drying the chick peas.

2. Materials and methods

2.1 Materials

2.1.1 Sample collection

The raw material, chickpeas was obtained from a local supermarket in Hyderabad.

2.1.2 Experimental setup

The laboratory scale batch type tray dryer, hot air oven and infrared dryer was used

2.2 Methodology

2.2.1 Sample preparation

Chickpeas (300g) were weighed and the initial moisture content was determined. The estimated initial moisture content was 8.5% on wet basis. The weighed chickpeas were humidified for 2 hours and the moisture content was increased to 35.6% (Cil and Topuz, 2010) [4]. This was taken as the initial raw material for carrying out the experiment.

2.2.2 Methods of drying

2.2.2.1 Hot air drying

Hot-air drying of chick peas in a common fixed bed method of drying. Hot-air drying samples were dried at 60ºC and 80 ºC using a hot-air drying oven for a period till a final moisture content of approximately 8.4% was obtained which was determined by the gravimetric method at 105°C, till the weight reached a constant value (AOAC, 1990) [2].

2.2.2.2 Tray drying

The tray dryer is the device used the drying of the wet products of the crude drugs, chemicals, powders or the granules etc. The product to be dried was spread on the trays in such a way that the hot air can circulate uniformly. The trays are arranged into the drying chamber after the set temperature is attained. The products are dried at 60ºC and 80ºC respectively. The weight of the sample was recorded at an interval of 20 minutes till the desired moisture content is obtained.

Drying kinetics of chick peas

The moisture content and drying rate was calculated at each time interval.

$$\text{Moisture content (\%)} = \frac{\text{(Initial weight – Final weight)}}{\text{Initial weight}} * 100$$

$$\text{Drying rate (g/min)} = \frac{\text{(Initial weight – Final weight)}}{\text{Time interval}}$$

2.2.2.3 Infrared drying

The infrared moisture balance is an instrument for measuring content of materials that do not change their chemical structure while losing water under exposure to infrared radiation. This instrument is widely used for testing soils in construction, chemicals, foods etc.

Since drying and weighing are simultaneous, the balance is specially useful for determining the % moisture in substances that quickly absorb moisture after drying. The input power to the infrared lamp can be continuously varied from 0-250W. As a result greater penetration of heat is possible. The balance scale is divided directly in moisture percentages from 0-100% in 0-2% divisions. Read % moisture lost, based upon initial weight of sample.

The % moisture is calculated from the formula,

$$P' = \frac{100\ P}{100-P}$$

Where;

P = % of moisture lost by sample.

P' = % of moisture on dry basis.

To assume complete drying, a hold time of for 1-3 minutes is given and the final moisture content is recorded.

3. Results and Discussion

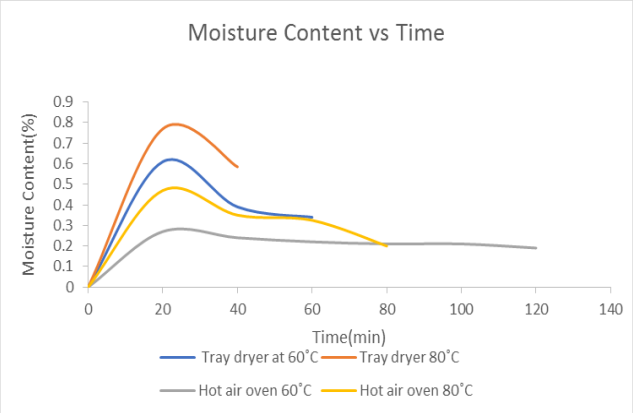

Fig 1: Effect of temperature on moisture content.

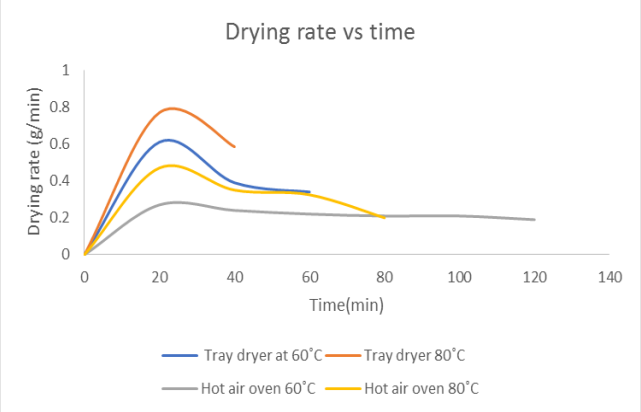

Fig 2: Effect of temperature on drying rate.

Time taken for drying the chick peas in infrared was found to be lower (T. Antal) than hot air oven and tray drier. Thus, the product dried in infrared was at a much better quality than the other driers. The rate of drying is higher for tray drier than hot air oven (Fig 2). The required moisture content was achieved at 25, 40 and 80 minutes at 80ºC in IR dryer, tray dryer and hot air oven respectively. It took 17, 60 and 120 minutes at 60ºC in in IR dryer, tray dryer and hot air oven respectively. Thus, it can be seen that the time taken for dryer in hot air oven is twice the time taken for drying in tray dryer (Fig 1). Thus, when compared between tray drier and hot air oven, tray drier showed improved and better efficiency than hot air oven. This is due to the uniform heating that is achieved in tray drier which leads to better air circulation. The rate of drying and the quality and time of drying is much more efficient (Singh, 2014) [12] in infrared drying when compared to tray and hot air oven drying (Fig 2). The product is less deteriorated in infrared dryer than tray and hot air oven dryers. Thus, for drying chick peas infrared dryer is much more economic and

efficient and it requires less adaptation time when compared to other dryers.

4. Conclusion

The study was mainly aimed in finding the best possible alternative method for drying the chickpeas. The advantages of infrared drying over other methods are clear and it is one of the better promising alternative method of drying among the tray drying and hot air oven drying.

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