JSAES
Journal of Sustainable Agricultural and Environmental Sciences

Print ISSN : 2735-4377
Online ISSN : 2785-9878
Homepage: https://jsaes.journals.ekb.eg/

Research Article

Comparison between the Drying Properties of Seedless Grapes, Natural Solar Drying and Microwave Drying

Mohamed S. Ghoname[1], Mohamed R. Darwesh[1,2], Eman S. Noiser[1*], and Mayie M. Amer[1]

[1]Agriculture Engineering Department, Faculty of Agriculture, Tanta University, Egypt.
[2]Faculty of Technology of Industry and Energy, Samannoud Technological University, Egypt.
[*] Correspondence: Eman, S. Nosier; emannosier660@gmail.com

Article info: -

- **Received**: 29 July 2024
- **Revised:** 10 August 2024
- **Accepted:** 25 August 2024
- **Published:** 27 August 2024

Keywords:
Seedless grapes; Natural-sun drying; Microwave; Drying; Moisture content

Abstract:

One of the most well-liked and delicious fruits in the world is the grape. In many regions of the world where grapes are grown, the drying process is a significant industry for grape preservation. This study attempts to compare the characteristics of drying seedless grapes using two drying methods, natural-sun drying and microwave drying. It shows that sun drying depends mainly on weather conditions, as the temperature ranged between 28 and 37 °C and the relative humidity ranged between 51 and 72%The incident solar radiation ranges from 266 to 1103 W/m2 during the experiment period. Natural-sun drying leads to contamination of the product because of its infestation with insects and microbes and thus leads to a decrease in the quality of the product, while microwave drying uses two powers, P80 and P100. We found that P100 uses less time compared to P80, and microwave drying preserves the product in terms of infestation by insects and dust. It shows that microwave drying is better in terms of saving drying time, preserving the product from insect infestation, and unifying the color of the product compared to natural sun drying. It takes more time and exposes the product to insect infestation and a difference in the color of the resulting product.

1. Introduction

Grape is one of the most significant fruit crops in the world due to its nutritional and therapeutic value. Grapes are good source of nutritional sugars, organic acids, and some vitamins. Grapes are a fantastic source of potassium, vitamins C, and B1. Kishmish is the name given to the seedless raisins. In addition to providing sweetness, raisins are a rich source of fibre, several minerals, and some vitamins.

Grape is one of the most economic and important fruit in the world and the second important fruit after citrus in Egypt. The world harvested area of grape in 2020 was 6.95 million hectares with a total production of 78034332 tons, while the total harvested area in Egypt was 71889 hectares and produced 1586342 tons (FAO, 2020).(Abdel-Salam , 2016) indicated that, table grapes face postharvest issues such as weight loss, shattering, rot, stem browning, and so on, which are key factors limiting storage term and access to distant markets. As a result, the purpose of this study was to identify appropriate strategies for resolving postharvest issues and improving the storage life of "Ruby seedless" grapes during cold storage or in marketing conditions. (Zemni et al.,2017) showed that, the enhancement of grape board, management, and promotion is essential, emphasizing the need for the adoption of progressively effective saving strategies. In this regard, drying, as the most proven food-safety technique, should be one of the methods that can meet this requirement by enhancing inferred grapes item quality, expanding their accessibility, and differentiating their exchange. (Surata et al., 2013) found that, one of the earliest methods used to process agricultural products is open sun drying, although this method occasionally results in items that cannot be sold on the international market because they don't meet the standards. (Sehdev, 2014) stated that, the drying process is the removal of water from the material by giving thermal energy to wet material. The water within the fruit is transported to the surface through diffusion and is removed from the surface with vaporization. (Adiletta et al., 2015) indicated that, the dehydration of fruit at high temperatures can adversely affect the fruit quality due to the loss of nutrients, flavour, texture, colour, and bioactive compounds, all of which demand a significant amount of energy. Studies on fruit drying conducted recently have used temperatures below 50 °C, longer drying times, and a greater final fruit water content of roughly 35%. (Bese et al.,2017) recommended that, drying is a process in which the water in a material is eliminated by supplying heat energy to the moist material. Diffusion brings the water from the fruit's inside to the surface, where it is subsequently eliminated through evaporation.

(Mennouche et al.,2019) stated that, Open sun drying (OSD) is the most generally used method for drying agricultural products such as vegetables, fruits, and grains, particularly in tropical and subtropical areas around the world. In this method, the products are usually spread outside, often over the prepared ground or mat, and exposed immediately to sun and wind. As a result, this method has some disadvantages: the harm of the product due to the injury of birds, animals, insects, and rodents, the degradation of the product caused by direct exposure to rain, solar radiation, wind, and dew, pollution due to wind-blown dirt, dust, debris, and ecological contamination, possible cracking of the material, growth of bacteria, and loss of germination ability.

(Lokhande et al., 2017) showed that, microwave drying has gained popularity over the past two decades to speed up the drying process and remove more water from agricultural products. Higher drying rates, shorter drying times, less energy use, and improved product quality are just a few benefits of microwave drying. Modern drying methods now strive to provide excellent quality with little increase in economic input while also improving drying processes by minimizing energy usage. **(**Besir et al., 2022) indicated that, although convectional drying has been practiced for a long time because of its ease of use and low cost, the lengthy procedure and high temperature result in substantial energy consumption. The rapid drying velocity and superior food quality of the microwave-drying method have led to its recent study as a convective drying method alternative. The process of microwave drying uses electromagnetic waves to heat objects in volume, which removes moisture from food by raising the temperature during microwave drying and applying an electromagnetic field. (Lin et al., 2022) illustrated that, microwave (MW) drying is a new technique that dries materials by converting electromagnetic energy into thermal energy. It has been widely utilized in the drying and processing of grains, fruits, vegetables, and aquatic products due to its quick drying rate and ease of operation. the impacts of MW drying power on the drying kinetics of fish and found that as MW power increased, drying time decreased, and that the MW power level was the primary factor influencing the colour change in the treated materials. So, the objectives of this paper are to study the effect of sun and microwave drying on drying properties of seedless grapes and study the effect of two microwave levels of power on drying properties of seedless grapes.

2. Materials and Methods

A dryer was manufactured for drying grapes using solar energy in the Zefta region, Gharbia, Egypt, in August and September 2023. The latitude and longitude angles for the specific location are (Φ is 30.81° N, 31.18° E), respectively.

2.1. Description of Natural-sun-drying system:

A natural-sun-drying mode was also carried out during this research work. It constitutes of a wooden drying tray 1m long and 1m wide, with a net dehydration surface of $1m^2$, a sheet made of iron and painted in a matte black color was placed under the wooden tray to attract sunlight. The dimension of the sheet is (1m long and 1m wide) with a net surface area of $1m^2$. The natural dryer is a wooden frame 0.09 m high from the ground. The upper surface of the natural solar dryer is covered with a mesh of perforated wire as clarified in Fig. 1a.

Fig.1a. Natural-sun-drying system.

Fig.1b. The dryer is the first day of drying.

Fig.1c. Dryer last day of drying.

2.2. Drying with microwave (MW):

In the MW drying process, a kitchen type microwave oven (MOM-C25BBE-BK) was used. Samples were dried within the microwave at 2 distinctive control levels (720 W (P80) and 900 W (P100)). All the drying operations were carried out with 150 g of fresh grapes. The drying prepare was connected for 20 s whereas applying control and holding up for 20. Whether the grapes reached the final dry matter content 81.1% (18% moisture content) was determined by monitoring their weight throughout the drying period.

2.3. Description of seedless Grapes samples:

During the 2023 harvest season, Fresh seedless grapes from the cultivar Thompson had purchased from a local producer of Dakhlyh Governorate. The enormous clusters of grapes were divided into smaller pieces, and the immature berries and external contaminants were eliminated. As a result, grape clusters of a non-uniform size that were free of bacterial and fungal damage were chosen for the experiment. Due to the unique structure of grape berries—which are coated in a waxy layer—the process of dehydrating seedless grapes to generate raisins is extremely laborious. To get rid of the wax layer, cause cracking, quicken the dehydration process, and achieve the right shade of smooth skin, Sulphiting is the most popular technique used to preserve fruits and prevent browning. Where sulfur is burned at a rate of 3-4 g/kg of whole fresh fruit, the grapes are first boiled in boiling water for 5 seconds, then placed in cold water for 2-3 minutes, after which samples are taken and placed in the refrigerator (evaporator), then placed The sulfur is in a cylindrical box that has an opening for the burning sulfur to escape to evaporate the samples, and it must be fixed the box is sealed tightly with a heat source provided, and after 4 hours, the refrigerator is opened for a quarter - half an hour to let the exhaust out, and then new matches are placed .

4.1. Determination of moisture content of grapes:

Three random samples were taken to measure the initial moisture content of grapes. The samples were weighed before drying them in the electric oven using a digital balance and the weight of the samples was as follows (2.270 g) (2.484 g) (2.601 g). Each sample was placed in a small cup and placed inside the oven at 78°C during 48 h even weight stability Official Analytical (AOAC, 2005). The initial moisture contents of grapes after pretreatment were on an average of 81.1(w.b.) according to (Khamtree et al., 2019) illustrated that, the initial moisture content of the fresh seedless white grapes was measured, which was observed to be between 78.78 and 81.23%.

5.1. Kinetics of solar drying for grapes by mathematical modeling.

5.1.1. Moisture Content (dry basis), (M.C. db.):

The beginning moisture content is calculated using the oven method, and the moisture content after each drying hour is calculated by using an electric balance to calculate the initial weight and the weight lost after each hour. The equation provided by is used to calculate the moisture loss (Wilcke ,1980)

$$M_c = \frac{w_i - w_f}{w_i} \, x \, 100$$

Where:
W_f = Final weight of the sample (g)
W_i = Initial weight of the sample (g)

5.1.2. Moisture content (wet basis), (M.C. w.b):

The % of moisture content on wet basis (M_{wb}) according to the following equation:

$$\% \, M_{wb} = \frac{mi - mf}{mi} \, x \, 100$$

Where:
m_i = initial mass of the sample
m_f = final mass of the sample

5.1.3. Drying Rate:

The drying rate is determined according to the following equation:

$$DR = \frac{\Delta M}{\Delta t}$$

Where:
ΔM = loss of the mass of the crop
Δt = interval of time

3. Results and Discussion

3.1. Drying time:

The drying time values of the grapes samples were subjected to microwave drying process on the sun and at two different powers (720 W (P80) and 900 W (P100)) are given in Table 1. It has been determined that 14 days for whole-dried grapes on the sun. Microwave drying is made on the highest power value grapes drying time for the drying operation 9 min P100, P80 was determined to be 10 min 20 s for drying.

Table 1. Drying time of grapes

Drying method	Time
Natural-sun-drying	14 days
P100	9 min.
P80	10 min and 20 s.

As a result, drying in the microwave seems to significantly reduce the drying time compared to drying in the sun. The increase in microwave power applied to the specimens caused a decrease in drying time. (Lokhande et al., 2017) study different microwave power drying process grapes were calculated from 180 to 5 minutes according to power microwave used.

3.2 Temperature and relative humidity:

Fig. 2 shows the hourly evolution of the measured average ambient temperature of sun drying grapes is presented. The surrounding air temperature was 32.95 °C, and the highest relative humidity seen was around 164%. The DHT11 sensor was used to measure the ambient temperature and relative humidity during the sun.

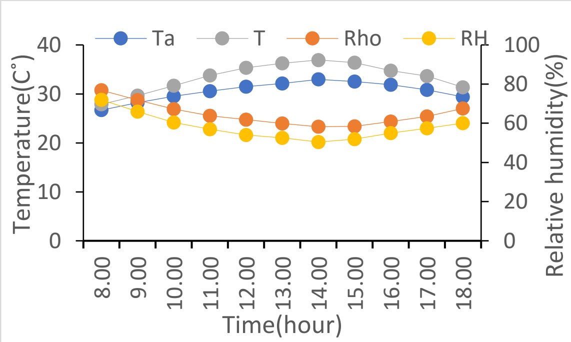

Fig.2. Average temperatures and humidity measured during the experiment period. (Air temperature (Ta), outside air relative humidity (Rho), air temperature inside the dryer (T) and air relative humidity inside the dryer (RH)).

The results from Fig. 2 reveal that an increase in ambient temperature leads to a decrease in relative humidity, and that the temperature inside the dryer is higher than the ambient temperature and therefore the humidity inside the dryer is lower.

3.3 Solar radiation:

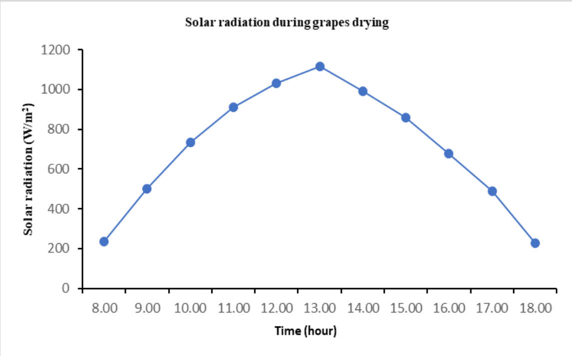

Fig.3. Average solar radiation measured hourly.

The results from Fig. 3 reveal that the raise the temperature, the higher the solar radiation, which leads to accelerating the drying process and thus reducing the drying period for grape samples.

3.4 Moisture content:

Fig. 4,5 shows the drying curve for grapes in the microwave drying. It was observed that heat removal increases due to increased microwave power, which indicates faster drying of the material and reduced drying time.

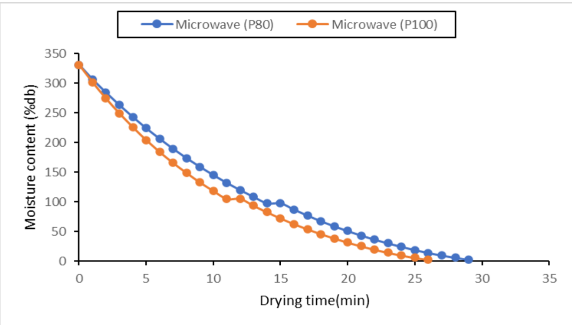

Fig.4. Difference in moisture content on dry basis of grapes Microwave (P80) and Microwave (p100) grapes drying in function of drying time.

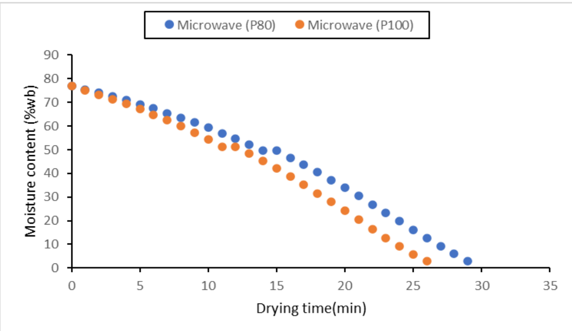

Fig.5. Difference in moisture content on wet basis of grapes Microwave (P80) and Microwave (p100) grapes drying in function of drying time.

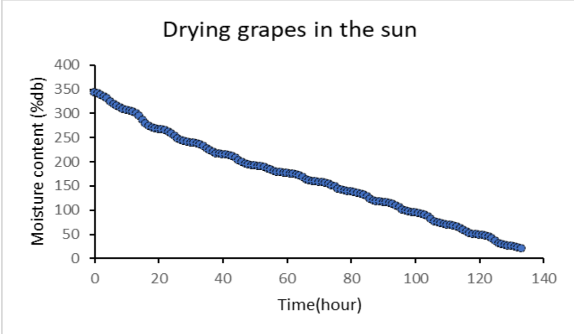

Fig.6. Difference in moisture content on dry basis of grapes drying in the sun with drying time.

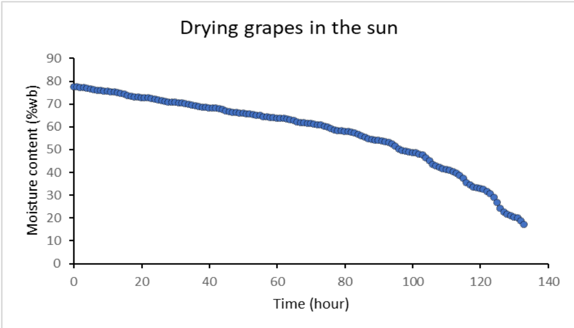

Fig.7. Difference in moisture content on wet basis of grapes drying in the sun with drying time.

It can be seen that moisture content decreases distinctly in accordance with drying time whether on a wet or dry basis. As shown in Fig. 7,8 the time demanded to dry grapes under an microwave (P80), microwave (P100) and open sun was 10 min 20s, 9 min and 2 weeks (140 h), respectively. According to (Williamson et al., 2010) stated that, raisins are made by sun-drying grapes for two to three weeks.

Conclusion

In this study, the drying characteristics of pretreated seedless grapes using three different modes of dryer (microwave (P100), microwave (P80) and natural-sun-drying) was investigated., The moisture percentage in fresh seedless grapes reached 81.1% and was measured using an electric oven, and the moisture percentage in raisins decreased to 18%. Natural solar drying is widely used due to its low costs and its dependence mainly on weather conditions, which exposes it to pollution where the temperature ranges from 28 and 37ºC, the relative humidity ranges from 51 and 72 %, and the incident solar radiation ranges from 266 and 1103 W/m^2. Therefore, drying with a microwave is better than natural drying in terms of saving time, and drying with a microwave P100 requires less time than drying with a microwave P80. Microwave drying preserves samples from insects and disease, while natural-sun-drying) exposes samples to insects and pests, and this leads to the production of a high-quality product.

References

Abdel-Salam,M.M. (2016). Using Some Postharvest Treatments to Improve the Storage Life and Marketing of "Ruby Seedless" Grapes. Assiut J. Agric. Sci.Vol 47 (2): 60 – 73.

Adiletta, G.; Russo, P.; Senadeera, W. and Matteo, M. (2016). Drying characteristics and quality of grape under physical pretreatment. Journal of Food Engineering. Vol 172: 9–18. [CrossRef]

AOAC (2005). Association of official analytical chemists. official methods of analysis, 18th Edition; Association of official analytical chemist international: North Frederic Avenue, Gaithersburg, Maryland, USA.

Beşe, A. V. (2017). Sun Drying of Cornelian Cherry Fruits (Cornus mas L.). Journal of Science and Technology. Vol 10(1): 68-77.

Besir,A.; Gül L.B.; Gökmen ,S. and Yazici F. (2022). Evaluating of Microwave Drying for Hawthorn Slice as Alternative to Convective Drying. Brazilian Archives of Biology and Technology. Vol 56(1):1-13. https://doi.org/10.1590/1678-4324-2022210614.

Food and Agriculture Organization of the United Nations (FAO. (n.d.). FAO Statistics.(2020). https://www.fao.org/faostat/ar/#data/QCL.

Gatea,A.A.(2011) . Performance evaluation of a mixed-mode solar dryer for evaporating moisture in beans. Journal of Agricultural Biotechnology and Sustainable Development. vol. 3(4): 65-71.

Khamtree, S.; Ratanawilai, T. and Nuntadusit, C. (2019). An approach for indirect monitoring of moisture content in rubberwood (Hevea brasiliensis) during hot air drying. Drying Technology. Vol 37(16): 2116- 2125. http://dx.doi.org/10.1080/07373937.2018.1563901.

Lin,Y.; Gao Y.; Li, A.; Wang, L.; Ai, Z.; Xiao ,H.; Li,J. and Li, X.(2022). Improvement of Pacific White Shrimp (Litopenaeus vannamei) Drying Characteristics and Quality Attributes by a Combination of Salting Pretreatment and Microwave. Foods. Vol 11: 1-17.

Lokhande,S.M.; Ranveer R.C.and Sahoo,A.K.(2017). Effect of microwave drying on textural and sensorial properties of grape raisins. International Journal of ChemTech Research.Vol 10. (5) :938-937.

Sandali, M.; Boubekri,A.; Mennouche ,D. and N. Gherraf . (2019). Improvement of a direct solar dryer performance using a geothermal water heat exchanger as supplementary energetic supply. An experimental investigation and simulation study. Renewable Energy. Vol 135 (1) : 186-196.

Sengar, S. H.; Mohod ,A. G. and Khandetod, Y. P. (2012)Experimental evaluation of rotary solar dryer for kokam fruit. Scholarly Journal of Agricultural Science. vol. 2(3): 62-69.

Wilcke, W.F. (1980). Low Temperature Solar Grain Drying Handbook. Midwest plane press, University of Illinois, Illinois, USA.

Williamson, G.; Carughi, A. (2010). Polyphenol content and health benefits of raisins. Nutrition Research. Vol 30 (8): 511-519. https://doi.org/10.1016/j.nutres.2010.07.005.

Zemni, H.; Sghaier, A.; Khiari, R.; Chebil ,S.; Ismail, H.B.; Nefzaoui, R. and Lasram,S. (2017). Physicochemical, phytochemical and mycological characteristics of italia muscat raisins obtained using different pre-treatments and drying techniques. Food and bioprocess technology. Vol 10 (3) :479-490.