Quality attributes of dried guava pulp using refractance window *Vs.* hot air drying

M. M .Hasan [1], N. EL-Badry [1], T. H. Ghanem [2] and A. Nasr [1,*]

[1] *Department of Food Science and Technology, Faculty of Agricultural, Al-Azhar University, Cairo, Egypt.*
[2] *Department of Products Process Engineering, Faculty of Agricultural Engineering, Al-Azhar University, Cairo, Egypt.*

*Corresponding author E-mail: aliq11150@azhar.edu.eg (A. Nasr)

ABSTRACT:

In recent years, refractance window drying (RWD) has attracted interest from academia and industry. So, this investigation's primary goal was to use RWD versus hot air drying (HAD) for drying guava pulp. This investigation comprises the ascertainment of Drying kinetics and quality assessment such as Rehydration ratio, Water activity, Solubility, Hygroscopicity, Bulk density, Hunter color values, *L*- Ascorbic acid, Total phenolic compounds, Total flavonoids and DPPH radical scavenging activity of produced guava powder. The data collected showed that the RW elapsed time for drying under three distinct circumstances (50, 60 and 70ᴼC) were 60, 25 and 15 min; respectively) has greater average drying efficiency values and a shorter elapsed drying time. One kilogram of guava powder was produced for less money using RW drying than hot air drying, with costs of 5.83, 8.01 times and 11.65 times of 50, 60, and 70ᴼC, respectively. Additionally, the RW drying under three distinct circumstances resulted in a higher value of Rehydration ratio, bulk density, Solubility, and hygroscopicity than the corresponding values of guava powder produced by hot air drying (60ᴼC for 480 min.). However, overall, the RW drying process resulted in a very significant retention of antioxidant substances including *L*-Ascorbic acid, total flavonoids and DPPH radical scavenging activity.

Keywords: guava powder; RW Drying; HA Drying; kinetics; physicochemical; color; antioxidant compounds; economical evaluation.

INTRODUCTION

Guava (*Psidium guajava L.*) is a favorite fruit in tropical and hot subtropical regions and is gaining popularity in European and North American markets due to its high potential for agro-industrial use and well-known antioxidant properties, which are primarily attributed to its content of carotenoids and vitamin C. (Dalla Nora *et al*., 2014 and Nunes *et al.*, 2016 ; Leiton-Ramírez *et al.*, 2020).

The presence of these active compounds may indicate their value in both cancer prevention and immune system stimulation. Although, guava is used in processing of nectar, juice, drink jam and syrup, dried guava (in powder form) is not as widely available as other products. Egypt produced 2.7 million tons of guava in 2019, according to the Ministry of Agriculture and the Food and Agriculture Organization (FAO) of the United Nations. (FAOSTAT, 2020). (recent production stat.)

Guava fruits have a relatively short shelf life due to their perishable nature; hence, it's necessary to keep them in a stable form such as dried guava.

A unique drying technique, Refractance Window (RW) turns liquid foods and other related biomaterials into valuable powders, flakes, or sheets. Refractance Window (RW) technology can used to dry fruit, vegetable, or herb purees or juices and producing goods with superior color, vitamin, and antioxidant retention. (Nindo and Tang, 2007).

Numerous studies used RW drying to dry different fruits and vegetables purees including strawberry and carrot puree (Abonyi *et al.,* 2002), pumpkin puree (Nindo *et al.,* 2003), tomato puree (Abul-Fadl and Ghanem, 2011), mango puree (Caparino *et al.*, 2012), guava (Ramadan *et al.*, 2023). Also, Leiton-Ramírez *et al.,* (2020) produced guava snacks using RW drying Castoldi *et al.,* (2015).

The flavor, color, nutritional value, and preservation of bioactive compounds in traditional drying methods such as hot air are negatively impacted by the product's exposure to high temperatures. The current study compares the quality characteristics of hot air dried guava with that dried using refractance window drying technology. It also seeks to do an economic evaluation of the powder produced.

MATERIALS AND METHODS:-

Materials:-

High-purity solvents and chemicals were acquired from El-Gomhoria Company for Chemicals and Drugs in Cairo, Egypt.

Guava fruits (*Psidium guajava L.)* was brought in October 2023 from El-Obour Market in Cairo, Egypt. Pest-free, uniformly sized guava fruits with little physical damage were selected were transferred the Laboratory of Food Science and Technology Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.

Technological methods:

Preparation of guava pulp:

Guava fruits were chopped with a knife and blended into a rough pulp (Braun AG Frank, 40-60 Hz/400W, Tipe MX 32, No. 4142, German). After that, a finisher with a 0.5 mm screen was used to remove the seeds and skins from the pulp. The produced guava pulp was divided into five guava parts; one part was used to examine fresh guava while the remaining parts were used one at a time for drying processes.

Drying of guava pulp:

Hot air-drying of guava pulp.

500 g of guava pulp were put in aluminum trays. (35× 25×4 mm) having a thickness of roughly 2 mm in hot air drying (HAD) The pulp was dried using a hot air dryer set at 60±5°C for 8 hr.

Refractance window drying of guava pulp.

500 g of guava pulp were put in a 40 x 40 mm glass-water contact with a coating thickness of roughly 1 to 1.5 mm in a dryer with a refractance window (RW). The refractance window drying was carried out with three different times and temperatures as follows: 50±5°C for 60 minutes, 60±5°C for 25 minutes, and 70±5°C for 15 minutes till the level of moisture attained 5–6%. Fig.(1) depicts the refractance window dryer assembly drawing.

After drying, the dried layer of guava pulp was removed from trays or glasses and crushed. The dry flakes were powdered and run through a 20-mesh screen in a lab disc mill. The produced powder was kept in a sealed plastic page at a temperature of -18±5°C.

Refractance-window dryer Fig.(1) is mainly constructed of water basin 80x60x10 cm parallelogram well insulated with glass wool fiber and the basin is covered with sealed glass sheet 4 mm thick. The basin is covered with transparent semi- cylindrical plastic sheet cover supported by semi-cylindrical frame of metal sheet. The following units are basic parts of the Refractance- window dryer :

The hot water circulation unit, which consists mainly of :-

two circulation pumps, one at the inlet and the other at the outlet.

two solenoid valves one at the inlet and the other is at the outlet.

Heating reservoir.

Two air bubbles-extracting tubes, one at the inlet and the other is at outlet.

Water Heater in the heating reservoir.

Electrical wire conductors

Air circulating unit which is a radial flow centrifugal fan of 0.22 kW.

Dryer supporting frame, which is 60x80x80 cm, of steel L-shaped angle of parallelogram shape.

control unit, which is used for controlling water flow at the inlet and at the outlet till the required water temperature is satisfied and it consists of digital temperature reading, temperature sensor Type-K and contactor.

Analytical methods:

Determination of moisture content.

The moisture content of fresh and dried guava pulp samples were ascertained through drying at 105 ± 1°C until sampled were reached to a constant weight. according to (AOAC., 2016).

Rate of drying and moisture content variations:-

The drying rate (drying curves) was determined from change in mass with time by assess the moisture content in tested guava samples according to (AOAC., 2016) during drying process every two hours for hot air-drying methods (HAD) and five minutes for Refractance window drying methods (RWD).

The Titratable acidity (TA):-

The Titratable acidity (TA) of fresh and dried guava pulp samples was ascertained using the methodology outlined by AOAC. (2016). TA was measured as citric acid equivalents and examined in triplicate.

Value of pH:-

The pH value of fresh and dried guava pulp samples was measured Table using a combined pH electrode at 25°C, a Jenway 3505 pH Meter (UK), as detailed in AOAC. (2016).

Total soluble solids (TSS):-

A centrifuge was used after homogenizing and drying the guava to determine the total soluble solids content. With the help of a refractometer from Carl Ziess in Jena, Germany, the soluble solids in the supernatant were measured using the method outlined by AOAC. (2016). The results were expressed as °Brix at 20°C.

Water activity:-

The activity of water (a_w) of dried banana slices required adding roughly 3 g of water to a sample cup. At 25 °C, the Aqualab model CX-2 m (Decagon Devices Inc., Pullman, WA, USA) was used to measure the a_w. (Gabas *et al.*, 2002; Lewicki and Lukaszuk, 2000).

Rehydration ratio (R.R.):-

The rehydration ratio (R.R.) was calculated by the method of Davoodi *et al.*, (2007). The information was measured using RR:

R.R.=Mrh/Mdh.

Whereas *Mdh* is the mass of the dried sample for the rehydration test (g) and *Mrh* is the mass of the rehydrated sample (g).

Solubility index:-

powder's solubility was determined according to the method of Mahendran (2010) using a mixer set to high speed, 10g of powder and 100 ml of distilled water were mixed for three minutes. The mixture was then centrifuged for three minutes at 20,000 x g using an Eppendorf C-5702 Japan centrifuge. 50 ml of the supernatant was taken out of the supernatant and oven-dried for six hours at 105°C on reweighed petri dishes. The difference in weight was used to calculate solubility.

Hygroscopicity:-

Hygroscopicity of dried samples were determined by the method of Goula and Adamopoulos (2008) as the weight increase per gram of powder after 90 minutes in an atmosphere with a relative humidity of 76%.

Bulk density:-

The guava powder's loose and packed bulk density was ascertained by transferring 10 g of guava powder to a 250 mL measuring cylinder and measuring its loose and packed volume (CRA, 1998).

Color index:-

A Konica Minolta Colorimeter (CR-300; Minolta, Osaka, Japan) was used to test the color values of fresh and dried guava pulp that had undergone various pretreatments. All evaluated samples had their CIE Lab tri-stimulus values *L* (lightness/darkness), *a* (redness/greenness), and *b* (yellowness/blueness) measured at three distinct intervals. Oberoi and Sogi (2015) equation was utilized to compute the overall color difference (ΔE).

Determination of L-Ascorbic acid content:

The *L*-Ascorbic acid concentration of fresh and dried guava pulp was determined using a titratable technique and 2, 6 dichlorophenol-indophenols according to AOAC. (2016). The outcome was given as milligrams of ascorbic acid per 100 grams of samples.

Total Phenolics:-

The modified Folin-Ciocalteu colorimetric method Singleton *et al.*, (1999) was used to measure the total phenolics (TPs) content of samples. Utilizing a UV/Vis spectrophotometer (Spekol 11, No. 849101), each sample was examined at 760 nm. The results were represented as gallic acid equivalents (GAE) per 100 g of dry matter (DM), with gallic acid serving as the benchmark. The standard curve's linear reading ranged from 0 to 600 milliliters (1 ug of gallic acid).

Total Flavonoids:-

The approach described by Toor and Savage (2006) and Zhishen *et al.*, (1999) was used to evaluate total flavonoids. Using a spectrophotometer (Spekol 11, No. 849101) to measure the sample's absorbance at 510 nm in comparison to a blank (water), the total flavonoids were calculated using the standard curve. Metrics used to express the flavonoid concentration were mg Rutin equivalents/100 g DM.

DPPH Radical Scavenging Method's Antioxidant Activity:

The free radical scavenging activity of guava pulp extracts was assessed by the method described by Brand-Williams *et al.*, (1995) as follows: 50 µL of an extract methanolic solution was put to 96-well microplates, along with 200 µL of a 0.1 mmol L-1 methanolic solution of DPPH. The mixture was then left to react at room temperature in the dark. A spectrophotometer (MRX Dynex Technologies) was used to quantify the decrease in DPPH absorbance at 520 nm every 5 minutes until the absorbance stabilized (30 min). The control was a DPPH solution without test samples, and the blank solution was methanol. Three duplicate analyses of each sample were carried out. The guava methanolic extracts' capacity to scavenge DPPH radicals was measured in milligrams of ascorbic acid equivalents per 100 grams.

Cost analysis:

According to El-Awady *et al.*, (1988), the entire cost per unit of the product is divided into:

Fixed costs were calculated according to the following equations:-

$$\text{Depreciation} = \frac{\text{cost now} - \text{salvage value}}{\text{total expected life in years}}$$

Whereas salvage = 10% of cost now.

Intereston investment = 1/2(depreciable cost) + (estimated savage)×interest rate.

Whereas the Interest rate is assumed 0.11.

Taxes and insureance = 1/2(depreciable cost) + (estimated savage)×combined rate.

Whereas combined rate =1.5%.

Operating costs:

Fuel, power and utilization

Maintenance and labor (maintenance = 3% cost now).

Statistical analysis:

To express the results, the standard error and mean values were utilized. Each analysis assay was carried out three times. With SPSS (version 22), the mean values were evaluated using a one-way analysis of variance (ANOVA) to look for significant differences ($p < 0.05$).

RESULT AND DISCUSSION

The physicochemical properties of fresh guava pulp:

Table (1) shows the physicochemical properties of fresh guava pulp, the results showed that was containing 84.50 % moisture , 12.30 % T.S.S, T.A. 0.57% as citric acid, pH value 4.30, water activity (a_w) 0.995, *L*-Ascorbic acid 650.00 mg /100g DM, Total phenolic compounds 60.98 mg GAE /100g DM, Total flavonoids 43.57 mg RU /100g DM and DPPH radical scavenging activity 31.45%. These findings are consistent with what was discovered by (Verma *et al.*, 2015 and Poonam *et al.*, 2022).

The impact of drying method on the moisture reduction rate during drying period (elapsed time) of dried guava pulp.

This study compares the elapsed time and moisture content of dried guava pulp for hot air drying (HAD) at 60 ºC and 1.5 m/s air velocity to the refractance window drying (RWD) method at 50ºC/ 60 min., 60ºC/25 min., and 70ºC/15 min. to determine the needed moisture level, drying curves are shown in Table Figures 2 and 3.

It can be seen from the data in Table (2) and Fig. (2 and 3) that hot air drying takes eight hours to produce dried guava pulp with moisture content of 6.23%. However, refractance window drying only took 60, 25, and 15 minutes at 50, 60, and 70 ºC to produce dried guava pulp with moisture content of 5.56, 6.78, and 5.95%, respectively. The high drying rate of RW is due to the combination of radiation and conduction during the drying process, the high mass and energy transfer that occurs in the food as a result of the hot water continuously circulating beneath the conveyor and the air circulation on the samples enhancing the convection mechanisms (Ortiz-Jerez *et al.*, 2015; Baeghbali *et al.*, 2016 and Jafari *et al.*, 2016).

The results also revealed that the falling rate period of guava pulp samples was more 8, 19 and 32 times, respectively when used the refractance window drying method at varying temperatures (50ºC, 60ºC and 70ºC) as compared to the hot air-drying.

So, refractance window drying might be a more effective substitute for hot air drying, this approach yields superior product quality and a higher drying rate (Abul-Fadl and Ghanem, 2011) and is an energy-efficient (re-circulation of water) quick drying method (Frabetti *et al.*, 2018; Leiton-Ramírez *et al.*, 2022; Kumar *et al.*, 2024).

These results are consistent with data from Santos *et al.*, (2022) who claimed that applying the refractance window drying to the dried material can substantially reduce the drying time and ensure the quality of the completed product.

Effect of Drying method on drying time of guava pulp.

Figure (4) illustrates the difference in the final drying time of guava dried with the hot air (HAD) and that dried with refractance window (RW). The data obtained revealed that the hot air-drying approach had longer drying time (8 hours) whereas refractance window was exhibited short drying time ranged from 60 min. to 15 min. which is lowered with increasing the temperature degree, since when the drying is achieved at 50ºC the drying time was 60 minutes, which is reduced to 25 min at 60 ºC while at a temperature of 70ºC it was 15 minutes. These results may be due to that the thin-film RW-drying system's rapid heat and mass transfer rates are what cause the quick drying speed (Abonyi *et al.,* 2002 ;Nindo *et al.,* 2003). These results in agreement with that of Hernández *et al.,* (2020) who reported that drying of apple slices by hot air drying was required 280 minutes, which is reduced to 50 minutes with RW at 95°C.

Impact of refractance window Vs. hot air drying on physicochemical properties of dried guava pulp.

From Table (3). It could be observed that the titratable acidity (%) as citric acid in guava pulp samples dried by using RWD was 1.64, 1.62 and 1.62%, for samples dried at 50 ºC/60 min., 60 ºC/25 min. and 70 ºC/15 min., respectively). On the other side, the guava pulp dried by HAD was had the lowest titratable acidity %, which recorded about 1.55. These results are in the line with that of **Poonam *et al.,* (2022)**. The reducing of titratable acidity may be due to Maillard reaction as reported by Sogi *et al.* (2015).

In regarding to pH value, the results indicated the same behavior as titratable acidity%, pH value of dried guava pulp dried by using HAD was 4.25 which is slightly reduced to 4.20, 4.19, and 4.18 for guava pulp samples dried by RWD at 50ºC/60 min., 60ºC/25 min. and 70 ºC/15 min., respectively. The current findings align with the earlier findings of Chauhan *et al.,* (2014).

Rehydration characteristics serve as a quality index for dried products and can reveal physical and chemical changes brought about by processing parameters. From the same Table (3). additionally, it was noted that rehydration ratios of guava pulp samples dried with RWD were 5, 5.25 and 5.20 for guava pulp samples dried by RWD at 50ºC/60 min., 60ºC/25 min. and 70ºC/15 min., respectively as compared to 3.52 for guava pulp sample dried with HAD. These results agreed with Ramadan *et al.,* (2023).

Based on the information gathered and displayed in the identical Table (3), it could be mentioned that the water activity (a_w) of dried guava was found to vary based on different drying methods. As the drying by the traditional method gave a much higher water activity (0.522) as compared to 0.422, 0.430 and 0.432 for guava pulp samples dried by RWD at 50ºC/60 min., 60ºC/25 min. and 70ºC/15 min., respectively. These findings are consistent with those discovered by Frabetti *et al.,* (2018).

In concern of, the solubility index of dried guava pulp the results cleared that hot air-dried guava pulp as have the lowest solubility index (58.34) as compared to 69.16, 69.96 and 69.92 for guava pulp samples dried by RWD at 50ºC/60 min., 60ºC/25 min. and 70ºC/15 min., respectively. These findings are consistent with those previously acquired by Patil *et al.,* (2014) and Chauhan *et al.,* (2014).

Similarly, the hygroscopicity values for RWD dried guava pulp samples were 13.06, 13.28 and 13.59 g/100 g d.b. for guava pulp samples dried by RWD at 50ºC/60 min., 60ºC/25 min. and 70ºC/15 min., respectively, while hot air-dried powder exhibited lower hygroscopicity (12.03 g/100 g d.b.) As shown in Table (3). These findings are consistent with what was discovered by Juarez-Enriquez *et al.,* (2017).

Regarding , Bulk density loose of guava pulp samples was observed to be 355, 346 and 342 kg/m^3 for guava pulp samples dried by RWD at 50ºC/60 min., 60ºC/25 min. and 70ºC/15 min., respectively as compared to 520 kg/m^3 for HAD pulp sample. while Bulk density packed of guava powder was observed to be 586, 572 and 566 kg/m^3 for guava pulp samples dried by RWD at 50ºC/60 min., 60ºC/25 min. and 70ºC/15 min., respectively as compared to 660 kg/m^3 for HAD pulp sample the outcomes matched those reported by Chirolia *et al.,* (2022).

The results also revealed that guava pulp samples that were dried using the refractance window exhibited the most color change (ΔE) because of the higher luminosity values that were obtained. The values of guava that were dried using the refractance window were 8.75, 8.39 and 8.10 for guava pulp samples dried by RWD at 50ºC/60 min., 60ºC/25 min. and 70ºC/15 min., respectively as compared to (16.66) for the guava that was air-dried.

Regarding L value the guava pulp samples exhibited higher L values than that of hot air-dried guava pulp, since L values were 46.52, 45.69 and 45.20 for guava pulp samples dried by RWD at 50^{o}C/60 min., 60^{o}C/25 min. and 70^{o}C/15 min., respectively as compared to 35.08 for HAD pulp sample

Additionally, the hot air-dried guava contained *a* value (5.23) more slightly than that found in the refractance window dried guava (4.92, 4.46 and 3.25) for guava pulp samples dried by RWD at 50^{o}C/60 min., 60^{o}C/25 min. and 70^{o}C/15 min., respectively. According to Deng and Zhao (2008), the tested sample's decreasing *L* value as a value increased showed an increase in browning color, which explains the color shift that occurs during the drying process. According to Tabtiang *et al.,* (2012) and Wang *et al.*, (2010), they found that a drop in *L* and an increase in *a* suggested an increase in browning discoloration, which was link ed to the Maillard reaction (a nonenzymatic browning reaction), caramelization, and pigment degradation. While *b* value recorded 11.25, 10.65 and 9.74, 11.25 and 10.65 for guava pulp samples dried by RWD at 50^{o}C/60 min., 60^{o}C/25 min. and 70^{o}C/15 min., respectively versus 12.5 for the hot air-dried guava. Better carotenoids retention for samples is the reason for this (Nyangena et *al.,* 2019). Finally, it can be said that refractance window drying preserves color better than hot air drying. RW drying results in superior color retention in guava. Shende and Datta (2019). The findings obtained demonstrated that, in comparison to the hot air-dried guava, the refractance window dried guava had much higher *L* and *b* values.

Impact of refractance Window Vs. Hot air drying on antioxidant components overall antioxidant capacity of dried guava pulp.

The variations in total antioxidant capacity and antioxidant components (such *L*-Ascorbic acid, total phenolic, and flavonoid components) between the RWD and HAD procedures for the dried guava that was generated are shown in Table 4 and Figs. 6, 7, 8, and 9.

As can be seen from the results of Table (4), which include antioxidant components such *L*-Ascorbic acid, phenolics, and flavonoids, fresh guavas have a significant amount of *L*-Ascorbic acid (650.00 mg/100g, on a dry weight basis). Furthermore, it was observed that fresh guava possessed a satisfactory quantity of phenolic and flavonoid compounds, with respective values of approximately 60.98 and 43.57 mg / 100 g on a dry weight basis. The outcomes align with the information gathered by Leiton-Ramírez *et al*., (2020) and Singh *et al.,* (2022) Regarding the impact of the HAD method versus the RWD method on the *L*-Ascorbic acid of the dried guava that was produced, it was observed from the data obtained in Table (4) and Fig. (5) that significant *L*-Ascorbic acid losses occurred during the drying processes for all different drying methods in the dried guava samples when compared to the fresh guava.

However, the maximum amount of *L*-Ascorbic acid (77.90%) was found in the dried guava made using the HAD method. This was greater than the corresponding amounts of *L*-Ascorbic acid lost in the dried guava made using the RWD method, which were 66.09%, 64.54, and 62.34% for guava pulp samples dried by RWD at 50^{o}C/60 min., 60^{o}C/25 min. and 70^{o}C/15 min., respectively. These findings demonstrated that the refractance window drying system improved the end products' quality standards when it was employed. In this case, utilizing RWD at temperature (50ºC, 60ºC, and 70ºC), particularly with RWD at temperature 50ºC drying methods, results in a higher retention of *L*-Ascorbic acid in dried guava than those obtained by HAD drying methods. It is evident that when drying in the refractive window, higher temperatures cause the value of vitamin C to decline more since the proportion of vitamin C falls with rising temperatures. The current findings concur with the information gathered by Hawlader *et al.,* (2006); Marques *et al.,* (2006); Sanjinez-Argandoña *et al.,* (2005); Chauhan *et al.,* (2014); Raghavi *et al.,* (2018) and Leiton-Ramírez *et al.,* (2020).

From the discussion above, it can be inferred that the reason why RW loses less vitamin C than HAD could be because it dries the fruit for shorter periods of time (15, 25, and 60 min.), which causes less oxidation of the fruit than HAD, which dries for a longer period of time (480 min.). These outcomes could also be explained by the fact that *L*-Ascorbic acid is more susceptible than most other food ingredients to the various drying conditions, including heat, oxygen, and light.

The results also showed that guava pulp samples dried by RW were recorded higher TPCs 173.22m 186.35 and 198.86 mg /100g (dm) for guava pulp samples dried by RWD at 50 ^{o}C/60 min., 60^{o}C/25 min. and 70^{o}C/15 min., respectively as compared to 130.20 mg/100 (dm). The results indicate that as the temperature used in RWD the TPCs of dried guava pulp is increased since the highest content was observed for guava pulp that dried at 70^{o}C/15 min. since high temperature releases phenolic chemicals that are bonded to other guava cell components (Saura-Calixto, 2012).

These findings could be explained by the low drying temperature, which may have totally deactivated the oxidative enzymes. This could have led to some phenolic material oxidation and a comparatively reduced phenolic content in the dried guava at lower temperatures. (Abul-Fadl and Ghanem, 2011)

Regarding the impact of drying techniques on total flavonoids, as shown by the obtained data Table (4) and Fig. (7), it can be inferred that, in comparison to the hot air-drying method, a significant amount of total flavonoids were retained in a wide range of guava pulp dried with RW drying at three different temperature conditions (50ºC/60min., 60ºC/25 min., and 70ºC/15 min.) containing total flavonoids of 144.28, 165.18, and 168.16 mg RU/100g as compared to 105.82 mg/100g for hot air dried guava pulp. The outcomes showed that the much longer drying time (480 min.) would cause the content of total flavonoids to significantly drop.

The effect of HAD as compared with RWD drying methods at three different conditions at temperature (50ºC, 60ºC and 70ºC), on the antioxidant activity of tested guava samples are presented in Table (4) and Fig. (8). The results showed that the guava dried with RWD at 70ºC had the highest scavenging capacity against DPPH compared to the other samples dried with RWD at 50ºC and 60ºC, which recorded 48.04 percent inhibition of DPPH free radicals. At 50ºC and 60ºC, the dried guava with RWD showed around 43.60 and 46.15% suppression of DPPH free radicals, respectively. On the other hand, the HAD-dried guava showed the lowest antioxidant activity, suppressing DPPH free radicals by a measured 26.81%. These findings might be explained by the antioxidant chemicals, such as phenolic and flavonoid compounds, that were discovered in the analyzed samples following their drying using various drying techniques, as previously shown in Table (4), fig. (9). Our results suggest a correlation between the DPPH reaction value with the studied samples and the content of phenolic compounds and flavonoids. This shows that the ability of guava fruit to scavenge radicals may be related to its phenolic components.

The ability of both guava pulp sample dried by HAD to quench the DPPH radical was found to be lower (26.81%) than guava pulp samples dried by RWD showed higher scavenging capacity against DPPH, especially the samples dried at 70ºC (48.04%).

In relation to this matter, it was demonstrated that strong correlations existed between the phenolic and flavonoid makeup of the guava samples under examination and the extent to which these constituents enhanced the antioxidant potential of dehydrated guava as impacted by diverse drying methodologies.

The economical evaluation for hot air drying and refractance window drying methods of guava powder.

The cost per LE/kg of dried product for guava powder in the current investigation is displayed in Table (5) and Fig. (9), using two distinct drying systems: refractance window drying (RWD) and hot air drying (HAD). In terms of economic cost, drying using a refractance window (RWD) exhibits substantial advantages over drying with hot air (HAD). In the current investigation, the production cost was employed to determine the economic evaluation of assist hot air drying in comparison to refractance window drying techniques used to produce dried guava.

In comparison to the hot air-drying system, the RWD drying system produced guava powder at temperatures of up to 5.83, 8.01, and 11.65 times lower per kilogram for dried tested items, respectively, at 50ºC, 60ºC, and 70ºC. The drying time has a direct impact on both fixed and running costs, which are highly influential. The RWD dryer's shorter drying time compared to the hot air-drying method results in much reduced power and operating expenses. This helps to explain why utilizing the RWD dryer produces one kg of guava powder at a cheaper cost than using the hot air-drying method.

The computed total costs of one kilogram of guava powder using refractance window dryer (RWD) were 12.55, 9.13, and 6.28 LE/ kg at different temperatures (50ºC, 60ºC, and 70ºC), according to the same data in Table (5) and Fig. (9). On the other hand, 73.14 LE/kg was the estimated total cost per kilogram of guava powder produced using a hot air dryer (HAD). The current findings are consistent with those previously acquired by Abul-Fadl and Ghanem (2011); Talukdar *et al.,* (2022) and Ramadan *et al.,* (2023).

The reduction in production costs can be attributed to the refractance window dryer's (RWD) rapid drying and short drying times, which took 60, 25 and 15 minutes at different temperatures (50ºC, 60ºC, and 70ºC), respectively. On the other hand, the hot air dryer's (HAD) lengthy drying time (480 min.) increased production costs.

Refractance window drying (RWD) offers economic benefits over hot air drying due to its simplicity, reduced drying time, and similar nutritional outcomes, as highlighted in the study.

When compared to hot air drying, far infrared assisted refractance window (FIR + RW) drying demonstrated a 60–75% reduction in drying time and a 38–45% reduction in energy usage, suggesting a more economical approach. Rajoriya *et al.*, (2023).Moreover, RW dryers are known for their energy efficiency, high-quality product outcomes, and potential for application in various sectors beyond food, such as pharmaceuticals and cosmetics, making them a cost-effective alternative to traditional drying methods like HA. (Kumar *et al.*, 2024).

Ultimately, the refractance window drying method in particular helps to drastically cut down on drying time, which lowers the cost of the dried goods. Generally speaking, RWD-related drying may satisfy the four main needs for food drying: product quality, cost of operation, energy efficiency, and operating speed. (Gunasekaran, 1999). Interest in RW dehydration has developed due to the growing need for foods with plant origins that are quickly dehydrated (Zhang and Xu, 2003).

Moreover, RW dryers are known for their energy efficiency, high-quality product outcomes, and potential for application in various sectors beyond food, such as pharmaceuticals and cosmetics, making them a cost-effective alternative to traditional drying methods like HA. (Kumar *et al.*, 2024). It should be noted, therefore, that the expenses listed in this work are conceptual and pertain to systems built on a laboratory scale. The process of scaling up might result in a large cost reduction. In contrast to hot air-drying processes, the RWD process is expected to maintain its cost competence since it achieves reduced electricity costs due to shorter processing times and simpler process equipment.

CONCLUSION

Finally, it could be concluded that RWD drying offers several advantages over hot air-drying methods for guava powder product. RW drying operates at low temperatures (50-70 °C) for a short duration (15-60 min), allowing for the retention of color, nutrients, and bioactive compounds like *L*-Ascorbic acid, phenolic compounds, Total flavonoids and total antioxidant capacity. This technology ensures minimal changes in the quality properties of food products, making it ideal for heat-sensitive materials. Furthermore, compared to hot air drying, RW drying uses less energy because of its great thermal efficiency caused by water recirculation.

REFERANCES:

Abonyi, B.I., Feng, H., Tang, J., Edwards, C.G., Chew, B.P., Mattinson, D.S., Fellman, J.K. 2002: Quality retention in strawberry and carrot purees dried with Refractance Window™ system. Journal of food science, 67(3), 1051-1056.

Abul-Fadl, M.M., Ghanem, T.H. 2011: Effect of refractance-window (RW) drying method on quality criteria of produced tomato powder as compared to the convection drying method.

AOAC International. Official Methods of Analysis of the Association of Official Analytical Chemists International.(2016). AOAC International: Rockville, MD, USA. 20th ed.

Baeghbali, V., Niakousari, M., Farahnaky, A. 2016: Refractance Window drying of pomegranate juice: Quality retention and energy efficiency. *Lebensmittel-Wissenschaft Technologie*, *66*, 34-40.

Brand-Williams, W., Cuvelier, M.E., Berset, C. 1995: Use of a free radical method to evaluate antioxidant activity. Food Sci. Technol., 28: 25-30.

Caparino, O.A., Tang, J., Nindo, C.I., Sablani, S.S., Powers, J.R., Fellman, J.K. 2012: Effect of drying methods on the physical properties and microstructures of mango (Philippine 'Carabao'var.) powder. Journal of food engineering, 111(1), 135-148.

Castoldi, M., Zotarelli, M.F., Durigon, A., Carciofi, B.A.M., Laurindo, J.B. 2015: Production of tomato powder by refractance window drying. Drying Technology, 33, 1463–1473.

Chang, C.H., Lin, H.Y., Chang, C.Y., Liu, Y.C. 2006: Comparisons on the Antioxidant Properties of Fresh, Freeze-Dried and Hot-Air-Dried Tomatoes. J. Food Eng. 77, 478–485.

Chauhan, A.K., Smita Singh, S.S., Singh, R.P., Abhai Kumar, A.K. 2014: Determination of antioxidant capacity, total phenolics and antimicrobial properties of spray-dried guava extract for value-added processing. J Food Process Technol., 5:9.

Chirolia, J.K., Rathour, S.S., Rajput, P., Bimal, S.S., Singh, K.V. 2022: Effect of Different Drying Methods on Physico-Chemical Attributes of Guava's Fruit Pulp Powder. International

Journal of Environment and Climate Change, 12 (11), 2751-2758.

CRA. 1998: Bulk density (B-16). Analytical methods. Washington, DC, USA: Corn Refiners Association, Inc.

Dalla Nora, C., Müller, C.D.R., de Bona, G.S., De Oliveira Rios, A., Hertz, P.F., Jablonkski, A., de Jong, E.V., Flôres, S.H. 2014: Effect of processing on the stability of bioactive compounds from red guava (Psidium cattleyanum Sabina) and guabiju (Myrcianthespungens). J. Food Compos. Anal., 34, 18–25.

Davoodi, M.G, Vijayanand, P., Kulkami, SG., Ramana, K.V.R. 2007: Effect of different pre-treatments and dehydration methods on quality characteristics and storage stability of tomato powder. LWT., 40: 1832-1840.

Deng, Y., Zhao, Y. 2008: Effect of pulsed vacuum and ultrasound osmopretreatments on glass transition temperature, texture, microstructure and calcium penetration of dried apples (Fuji). LWT Food Sci Technol 41(9):1575–1585.

El-Awady, M.N., Mosutafa, A.M., El-Gindy, A.M., Genaidy, M.A. 1988: A trial on solar energy drying for agricultural products with simple setup. Masr J. Ag. Eng., 5(3): 377-392.

FAOSTAT, 2020: Countries - Select All; Regions - World + (Total); Elements - Production Quantity; Items - Guava; Year – 2019.

Frabetti, A.C.C., Durigon, A., Laurindo, J.B. 2018: Effect of process variables on the drying of guava pulp by cast-tape drying. Lwt, 96, 620-626.

Gabas, A.L., Menegalli, F.C., Ferrari, F., Telis-Romero, J. 2002: Influence of drying conditions on the rheological properties of prunes. *Dry.Technol., 20*, 1485–1502.

Goula, A.M., Adamopoulos, K.G. 2008: Effect of maltodextrin addition during spray drying of tomato pulp in dehumidified air: II. Powder properties. Dry. Technol. 26 (6), 726–737.

Gunasekaran, S. 1999: Pulsed microwave-vacuum drying of food materials. Drying Technology, 17(3): 395-412.

Hawlader, M.N., Perera, C., Tian, M., Yeo, K. 2006: Drying of guava and papaya: Impact of different drying methods. Dry. Technol., 24, 77–87.

Hernández, Y., Ramírez, C., Moreno, J., Núñez, H., Vega, O., Almonacid, S., Pinto, M., Fuentes, L., Simpson, R. 2020: Effect of Refractance Window on dehydration of osmotically pretreated apple slices: Color and texture evaluation. *Journal of Food Process Engineering*, *43*(2),e13304.

Jafari, S.M., Azizi, D., Mirzaei, H., Dehnad, D. 2016: Comparing quality characteristics of oven-dried and Refractance Window-dried kiwifruits. Journal of Food Processing and Preservation, 40(3), 362–372.

Juarez-Enriquez, E., Olivas, G.I., Zamudio-Flores, P.B., Ortega-Rivas, E., Perez-Vega, S., Sepulveda, D.R. 2017: Effect of water content on the flowability of hygroscopic powders. Journal of Food Engineering, 205, 12-17.

Kumar, M., Madhumita, M., Prabhakar, P.K., Basu, S. 2024: Refractance window drying of food and biological materials: Status on mechanisms, diffusion modelling and hybrid drying approach. Critical reviews in food science and nutrition, 64(11), 3458-3481.

Leiton-Ramírez, Y.M., Ayala-Aponte, A., Ochoa-Martínez, C.I. 2020: Physicochemical properties of guava snacks as affected by drying technology. Processes, 8(1), 106.

Lewicki, P.P. Lukaszuk, A. 2000: Changes of rheological properties of apple tissue undergoing convective drying. *Dry. Technol.*, 18,707–722.

Mahendran, T. 2010: Physico-chemical properties and sensory characteristics of dehydrated guava concentrate effect of drying method and maltodextrin concentration. Tropical Agricultural Research and Extension, 13(2),48-54.

Marques, L., Silveira, A., Freire, J. 2006: Freeze-drying characteristics of tropical fruits. Dry. Technol., 24, 457–463.

Nindo, C.I., Tang, J. 2007: Refractance Window dehydration technology: A novel contact drying method. *Drying Technology*, *25*(1), 37-48.

Nindo, C.I., Feng, H., Shen, G.Q., Tang, J., Kang, D.H. 2003: Energy utilization and microbial reduction in a new film drying system. *Journal of Food Processing and Preservation*, *27*(2), 117-136.

Nunes, J.C., Lago, M.G., Castelo-Branco, V.N., Oliveira, F.R., Guedes, A., Perrone, D., Monteiro, M. 2016: Effect of drying method on volatile compounds, phenolic profile and antioxidant capacity of guava powders.Food Chem., 197, 881–890.

Nyangena, I.O., Owino, W.O., Imathiu, S., Ambuko, J. 2019: Effect of pretreatments prior to drying on antioxidant properties of dried mango slices. Scientific African, 6, e00148.

Oberoi, D.P.S., Sogi, D.S. 2015: Drying Kinetics, moisture Diffusivity and Lycopene Retention of Watermelon Pomace in Different Dryers. J. Food Sci.Technol., 52: 1–8.

Ortiz-Jerez, M.J., Gulati, T., Datta, A.K., Ochoa-Martínez, C.I. 2015: Quantitative Understanding of Refractance Window™ Drying. *Food and Bioproducts Processing, 95*, 237–253. 10.1016/j.fbp.2015.05.010.

Patil, V., Chauhan, A.K., Singh, S.P. 2014: Influence of spray drying technology on the physical and nutritional properties of guava powder. International Journal of Current Microbiology and Applied Sciences, 3(9), 1224-1237.

Poonam, K.V., Bimal, S.S., Rajput, P., Rathour, S.S., Chirolia, J.K. 2022: Effect of Different Drying Methods on Physico-Chemical Attributes of Guava's Fruit Pulp Powder. International Journal of Environment and Climate Change, 12(11), 2751-2758.

Raghavi, L.M., Moses, J.A., Anandharamakrishnan, C. 2018: Refractance window drying of foods: A review. J. Food Eng., 222, 267–275.

Rajoriya, D., Bhavya, M.L., Hebbar, H.U. 2023: Far infrared assisted refractance window drying: Influence on drying characteristics and quality of banana leather. Drying Technology, 41(13), 2143-2155.

Ramadan, A.H., Ghanem, T.H., Eissa, A.S. 2023: Some engineering factors affecting referactance window drying of guava. Al-Azhar Journal of Agricultural Engineering, 4(1), 10-20.

Sanjinez-Argandoña, E., Cunha, R., Menegalli, F., Hubinger, M. 2005: Evaluation of total carotenoids and ascorbic acid in osmotic pretreated guavas during convective drying. Ital. J. Food Sci., 17, 305–314.

Santos, V.C.S., Souza, R.L.D., Figueiredo, R.T., Alsina, O.L.S.D. 2022: A review on refractance window drying process of fruits and vegetables: its integration with renewable energies. Brazilian Journal of Food Technology, 25, e2021153.

Saura-Calixto, F. 2012: Concept and health-related properties of nonextractable polyphenols: The missing dietary polyphenols. Journal of Agricultural and Food Chemistry, 60(45), 11195-11200.

Shende, D., Datta, A.K. 2019: Refractance window drying of fruits and vegetables: A review. Journal of the Science of Food and Agriculture, 99(4), 1449-1456.

Singh, K.V., Chirolia, J.K., Rathour, S.S., Rajput, P., Bimal, S.S. 2022: Effect of Different Drying Methods on Physico-Chemical Attributes of Guava's Fruit Pulp Powder. International Journal of Environment and Climate Change, 12(11), 2751-2758.

Singleton, V.L., Orthofer R., Lamuela-Raventos, R.M. 1999: Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. Oxidants and Antioxidants, Part A., 299: 152-178.

Sogi, D.S., Siddiq, M., Dolan, K.D. 2015: Total phenolics, carotenoids and antioxidant properties of Tommy Atkin mango cubes as affected by drying techniques. LWT-Food Science and Technology, 62(1), 564-568.

Tabtiang, S., Prachayawarakon, S., Soponronnarit, S. 2012: Effects of osmotic treatment and superheated steam puffing temperature on drying characteristics and texture properties of Banana slices. *Dry. Technol.* 30, 20–28.

Talukdar, P., Mondal, I.H., Uppaluri, R.V. 2022: Techno-economic Efficacy of Refractance Window Dried Curcuma Longa. In North-East Research Conclave (pp. 81-98). Singapore: Springer Nature Singapore.

Toor, R.K., Savage, G.P. 2006: Effect of semi-drying on the antioxidant components of tomatoes. Food Chemistry, 94: 90-97.

Wang, R., Zhang, M., Mujumdar, A.S. 2010: Effect of osmotic dehydration on microwave freeze-drying characteristics and quality of potato chips. Drying Technology, 28(6): 798-806.

Zhang, M., Xu, Y.Y. 2003: Research developments of combination drying technology for fruits and vegetables at home and abroad. J. Wuxi University of Light Industry, 22(6): 103-106.

Zhishen, J., Mengcheng, T., Jianming, W. 1999: The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. Food chemistry, 64(4), 555-559.

Verma, M., Singh, J., Kaur, D., Mishra, V., Rai, G.K. 2015: Effect of various dehydration methods and storage on physicochemical properties of guava powder. Journal of Food Science and Technology, 52, 528-534.

Table 1: The physicochemical properties of guava pulp.

Properties		guava pulp
Moisture (g/100 g fresh pulp)		84.50±4.56
T.S.S (%)		12.30±0.62
T.A. % (as citric acid)		0.57±0.03
pH value		4.30±0.22
Water activity (a_w)		0.995±0.04
L- Ascorbic acid (mg /100g DM)		650.00±32.5
Total phenolic compounds (mg GAE /100g DM)		60.98±2.95
Total flavonoids (mg RU /100g DM)		43.57±2.20
DPPH radical scavenging activity%		31.45±1.50
Color parameters	*L**	50.92±2.45
	*a**	2.64±0.13
	*b**	16.95±0.8

GAE: gallic acid equivalents; RU: Rutin ; d.b. : dry basis; DPPH; 2,2,-diphenyl-1-picrylhydrazyl; the data is presented as mean ±SD.; standard deviation (n = 3): *L*: lightness/darkness; *a:* redness/greenness; *b* :yellowness/blueness

Table 2: Effect of hot air drying (HAD) and refractance window drying (RWD) on the moisture content (%) of dehydrated guava pulp.

Moisture content (%) of Guava during drying by HAD and RWD					
HAD Drying time (hr.)	(HAD)*	RWD Drying time (min)	(RWD)**		
	60 °C		50 °C	60 °C	70 °C
0	84.50	0	84.50	84.50	84.50
2	63.30	5	80.30	67.1	70.4
4	37.60	10	70.19	36.98	31.02
6	18.70	15	52.60	26.16	5.95
8	6.23	20	45.25	9.92	
		25	34.60	5.78	
		30	24.22		
		35	20.60		
		40	12.00		
		45	8.20		
		50	7.60		
		60	5.56		

*Air temperature ** Water temperature ; HAD: Hot Air Drying, RWD :Refractance Window Drying

Table 3: Effect of refractance window drying on physicochemical properties of dried guava as compared with hot air drying (Means± SD).

Physicochemical properties		Dried guava by different drying methods			
		hot air drying	Refractance window drying		
		60 °C	50 °C	60 °C	70 °C
T.A. % (as citric acid)		1.55[a]±0.02	1.64[a]±0.03	1.62[a]±0.043	1.62[a]±0.04
pH value		4.25[a]±0.18	4.20[a]±0.20	4.19[a]±0.18	4.18[a]±0.17
Rehydration ratio		3.52[b]±0.30	5.35[a]±0.26	5.25[a]±0.28	5.20[a]±0.30
Water activity (a_w)		0.522[a]±0.03	0.422 [b]±0.02	0.430[b]±0.03	0.432[b]±0.03
Solubility index (g/100 g d.b.)		58.34[b]±2.60	69.16[a]±2.80	69.96[a]±3.90	69.92[a]±4.00
Hygroscopicity (g/100 g d.b.)		12.03[b]±0.65	13.06[a]±0.70	13.28[a]±0.72	13.59[a]±0.75
Bulk density, loose (kg/m^3 w.b.)		520[a]±25.50	355[b]±20.00	346[b]±18.00	342[b]±16.00
Bulk density, packed (kg/m^3 w.b.)		660[a]±32.00	586[b]±26.00	572[b]±28.00	566[b]±30.00
Hunter color values	*L*	35.08[c]±1.70	46.52[a]±1.85	45.69[b]±1.80	45.20[b]±1.82
	a	5.23[a]±024	4.92[a]±0.22	4.46[ab]±0.20	3.25[b]±0.18
	b	12.50[a]±0.62	9.74[b]±0.45	10.65[ab]±0.50	11.25[a]±0.52
	Δ*E*	16.66[a]±0.80	8.75[b]±0.44	8.39[b]±0.42	8.10[b]±0.38

Each mean value within the identical letters on the identical row is significantly different at $p < 0.05$.
L: lightness/darkness; *a:* redness/greenness; *b* :yellowness/blueness; ΔE: the total color difference or change in color ; d.b. : dry basis ; w.b. : wet basis

Table 4: Impact drying of refractance Window method on antioxidant components and the guava's overall antioxidant capacity after drying as opposed to hot air drying (Means± SD).

Antioxidant compounds (mg/100g DM)	HAD	Dried guava at different temperatures by RWD		
		50 °C	60 °C	70 °C
L- Ascorbic acid	143.6[c] ±6.5	244.76[a] ±12	230.5[ab] ±11.5	220.4[b] ±10.5
Total phenolic compounds	130.20[c] ±6.2	173.22[b] ±8.5	186.35[ab] ±9.2	198.86[a] ±9.5
Total flavonoids	105.82[c] ±5.1	144.28[b] ±7.2	165.18[a] ±8.3	168.16[a] ±8.0
total antioxidant capacity (TAC) DPPH radical scavenging activity%	26.81[c] ±1.30	43.60[b] ± 2.20	46.15[ab] ±2.00	48.04[a] ±2.50

HAD; hot air drying; RWD; refractance Window drying :DPPH; 2,2,-diphenyl-1-picrylhydrazyl Data are expressed as mean ±SD; standard deviation (n = 3). Means in the same row with different letters are significantly (P≤ 0.05).

Table 5: Cost estimation for hot air drying (HAD) and refractance window drying (RWD) of guava pulp.

Items	HAD	RWD 50ºC	RWD 60ºC	RWD 70ºC
Depreciation.	4500 LE/year		1800 LE/year	
Interest on investment.	319 LE/year		797 LE/year	
Taxes and insurance.	1087 LE/year		435LE/year	
Maintenance and labor.	1500 LE/year		600 LE/year	
Electricity costs	5760		3600 LE/year	
the operating cost/ year	13166		7.232	
Total production/ year	180	576	792	1.152
Total costs LE/ kg	73.14	12.55	9.13	6.28

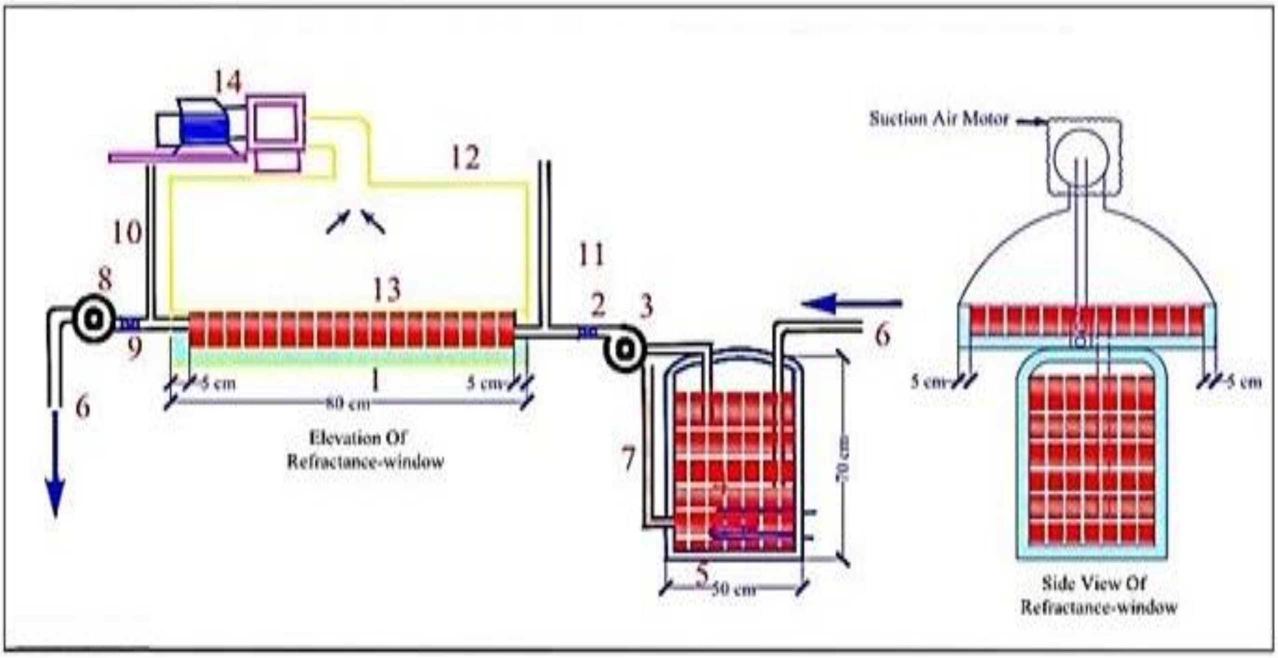

Figure 1 : Cross Section in Refractance-window dryer
1- Well Insulated water basin.2- Water Intel sex valve.3- Intel Water pump.4- Water Heater.
5- Cylinderical well ensulated water tank.6- Water inletFeed back water.7- Water scale
8- Feedback pump.9- Water outlet sex valve.10- air bubles extractor70cm leng.11- Heated Water
12-Semi cylinerical shell for basin 13-well sealed glass sheet 4mm thick14-suction Airmotor

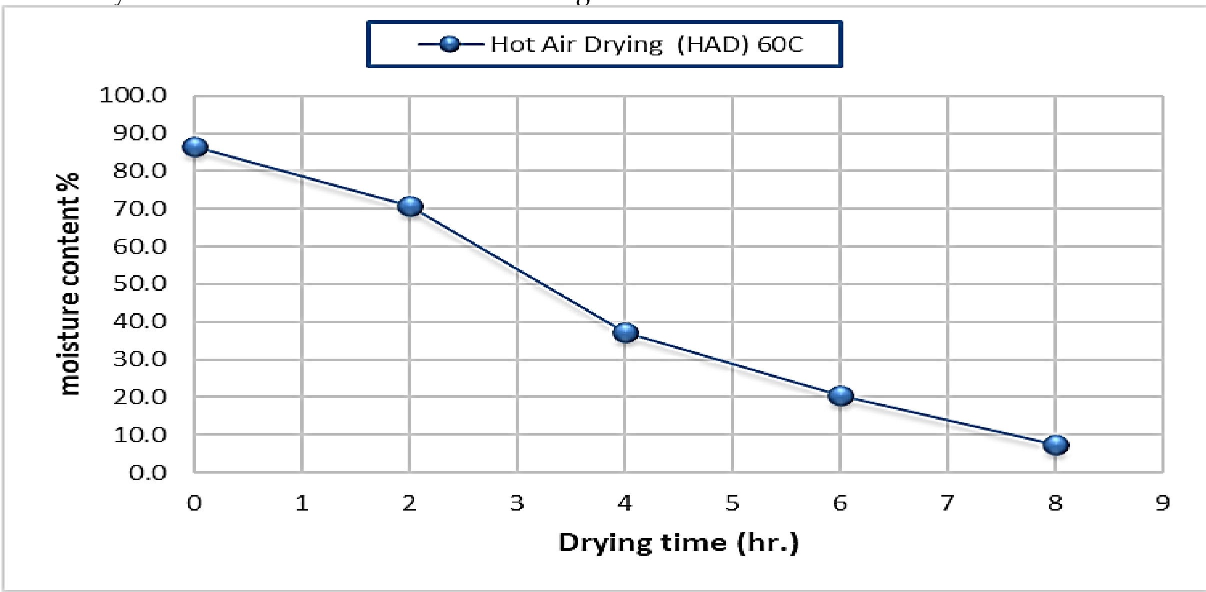

Figure 2: The drying rate of guava dried by Hot Air Drying (HAD) method.

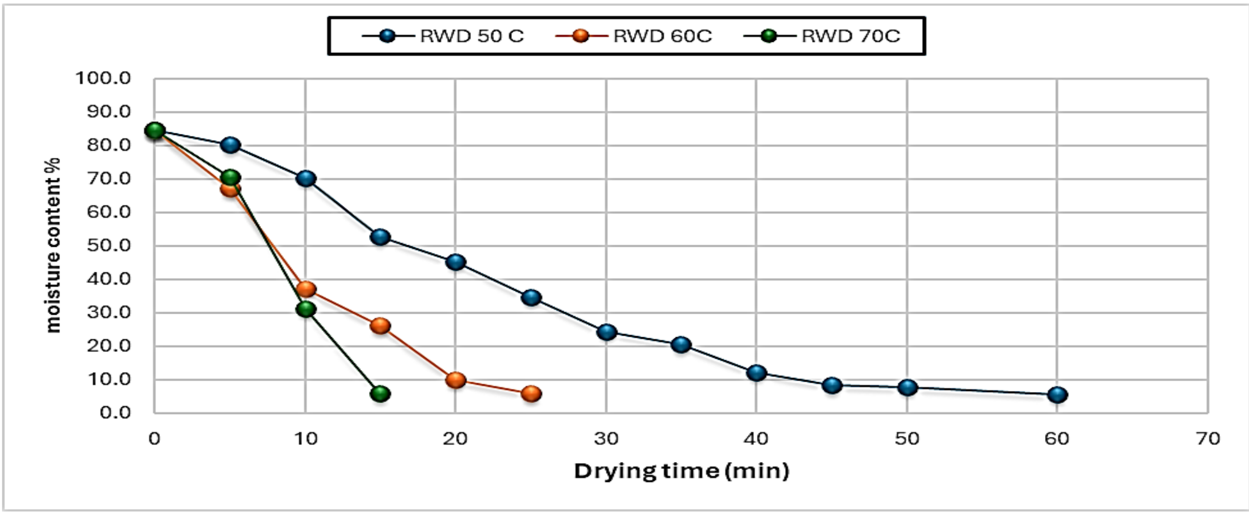

Figure 3: The drying rate of guava dried by Refractance Window Drying (RWD) method.

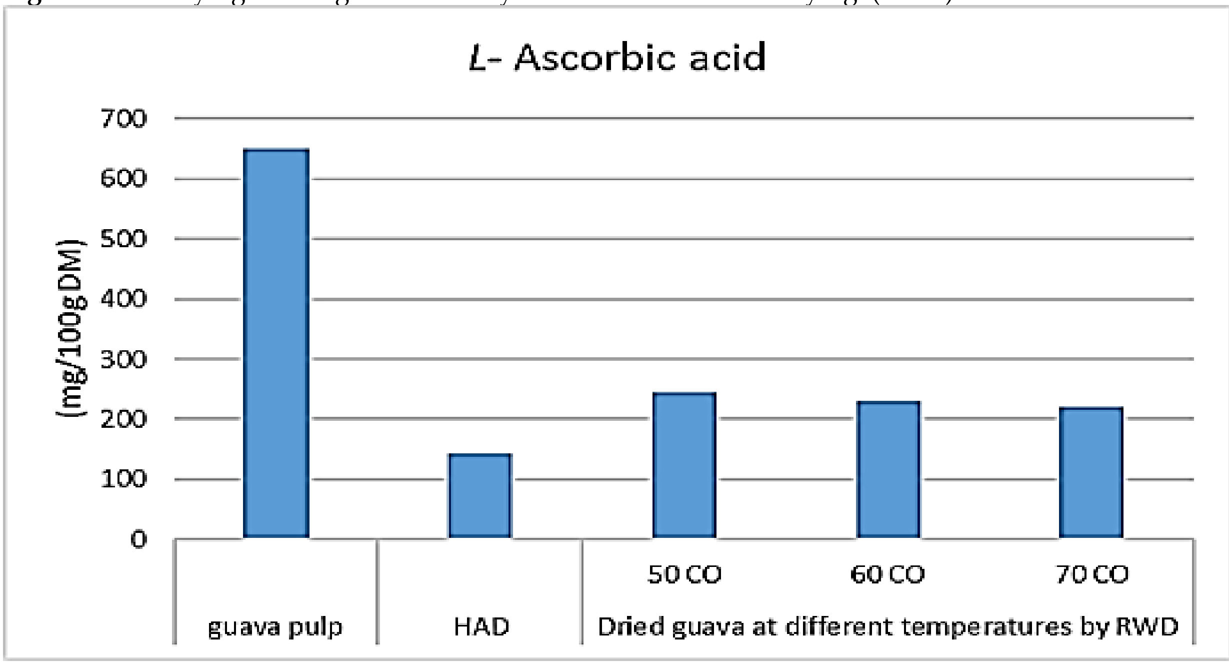

Figure 4: Effect of refractance Window drying method on *L*- Ascorbic acid of guava dried as compared with the hot air drying

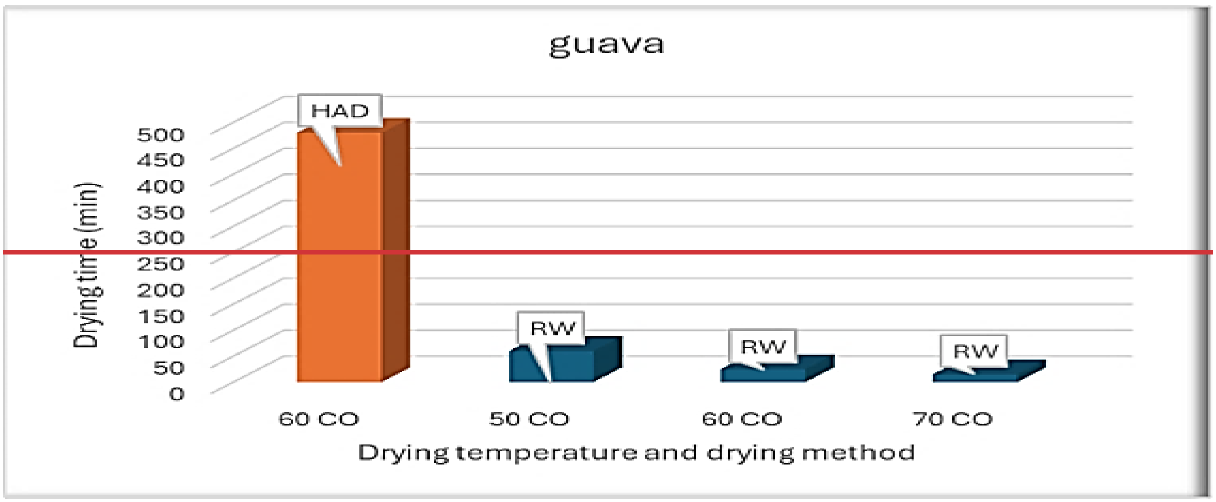

Figure 4: Drying time of dehydrated guava using HAD method as compared to RWD method

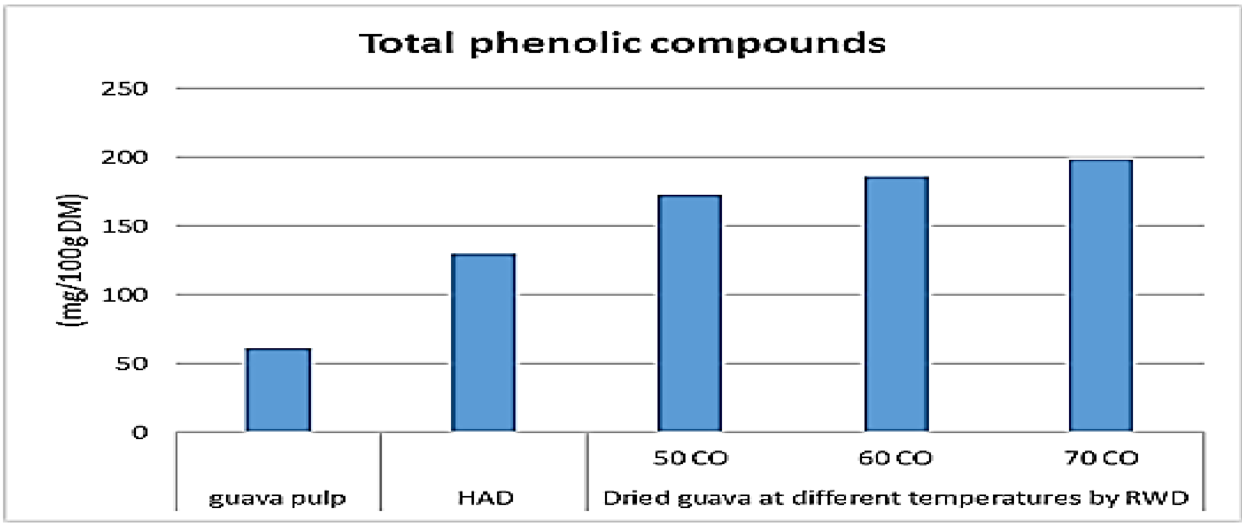

Figure 5: Effect of refractance Window drying method on Total phenolic compounds of guava dried as compared with the hot air drying

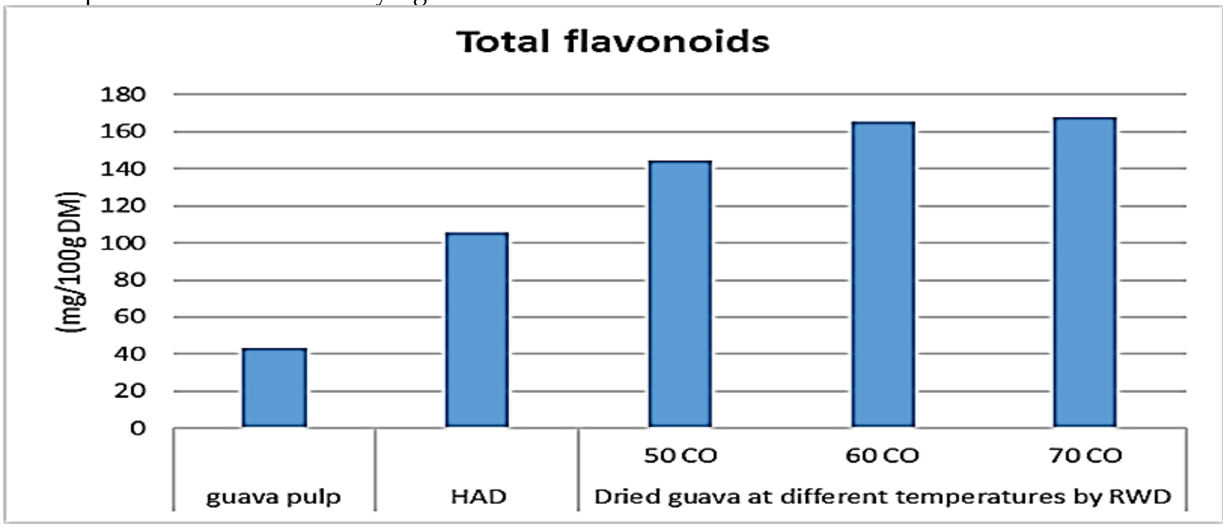

Figure 6: Effect of refractance Window drying method on Total flavonoids of guava dried as compared with the hot air drying

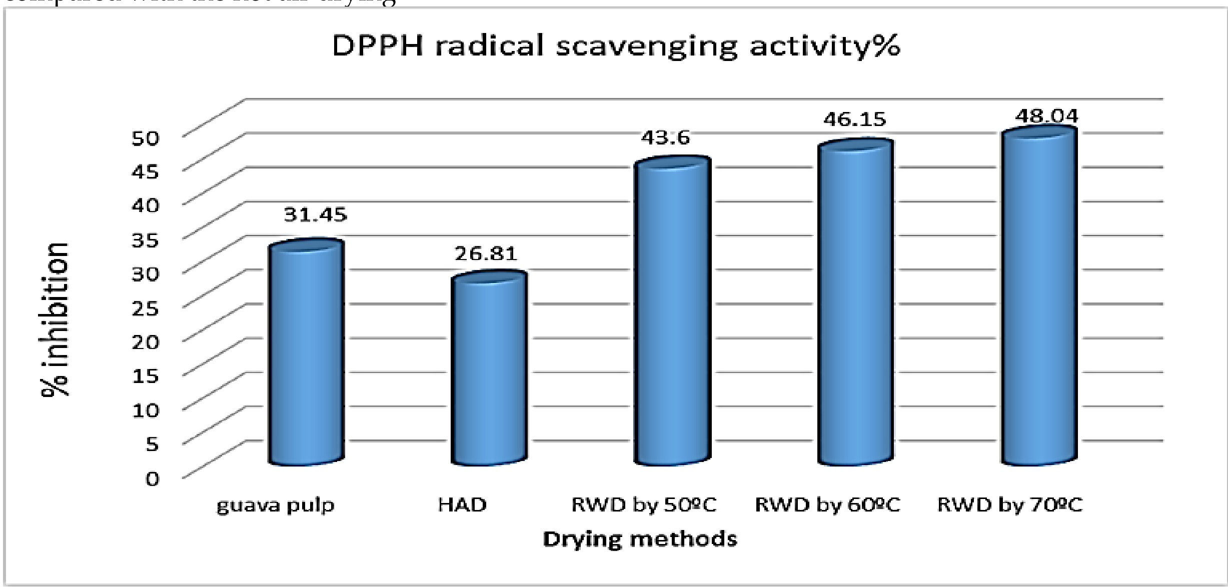

Figure 7: Effect of refractance Window drying method on total antioxidant capacity of guava dried as compared with the hot air drying.

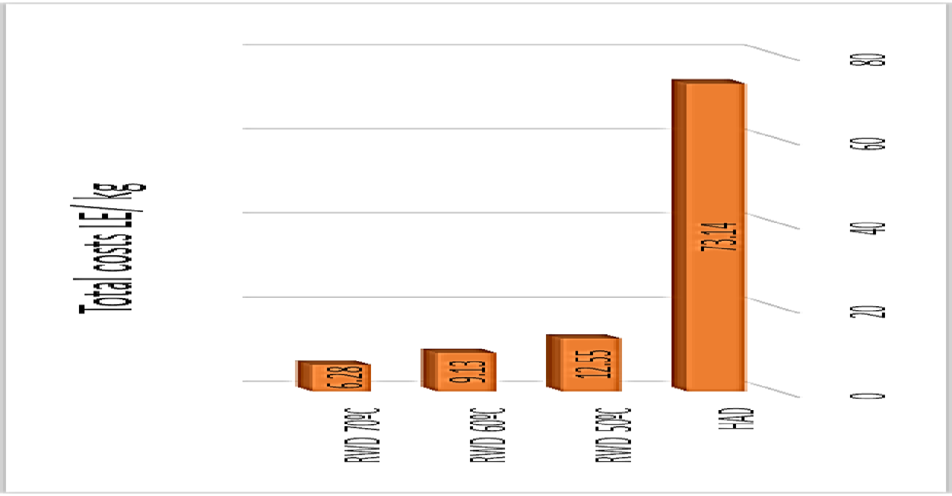

Figure 8: The production costs LE/Kg for hot air drying compared to refractance window drying methods of guava powder.

صفات الجودة للب الجوافة المجفف باستخدام التجفيف بالنافذة الانعكاسية مقارنة بالتجفيف بالهواء الساخن

محمد محسن حسن [1], ناصر البدرى عبد اللاه [1,*], طارق حسين غانم [2], على نصر بدوى [1]

[1]قسم علوم وتكنولوجيا الاغذية, كلية الزراعة, جامعة الازهر, القاهرة, مصر

[2]قسم هندسة تصنيع المنتجات الزراعية, كلية الهندسة الزراعية, جامعة الازهر, القاهرة, مصر

* البريد الإلكتروني للباحث الرئيسي:aboumohsen2020@yahoo.com

الملخص العربي:

في السنوات الأخيرة زاد الاهتمام بالتجفيف بالنافذة الانعكاسية في الأوساط الأكاديمية والصناعية. لذا، كان الهدف الأساسي لهذا البحث هو دراسة صفات جودة مسحوق الجوافة المُنتج باستخدام طريقة التجفيف بالنافذة الانعكاسية ومقارنتها بالتجفيف بالهواء الساخن، والتي يصُعب تجفيفها باستخدام الطُرق التقليدية. تشمل هذه الدراسة دراسة كلا من حركة التجفيف وتقييم صفات الجودة مثل نسبة التشرب، والنشاط المائي، والذوبان، والرطوبة، والكثافة الظاهرية، وقياس اللون، وحمض الأسكوربيك، والمركبات الفينولية الكلية، والفلافونويدات الكلية، والنشاط المضاد للأكسدة لمسحوق الجوافة المُنتج. أظهرت البيانات التي تم جمعها أن الوقت المنقضي للتجفيف بالنافذة الانعكاسية في ظل درجات الحرارة (50 و60 و70م°) كان 60 و25 و15 دقيقة على التوالي. حيث اظهر التجفيف بالنافذة الانعكاسية قيم أكبر لكفاءة التجفيف ووقت تجفيف اقل. وكان إنتاج كيلوجرام واحد من مسحوق الجوافة باستخدام تجفيف بالنافذة الانعكاسية اعطي تكاليف اقل بكثير حيث كانت التكاليف اقل بنسبة 5.83و 8.01 و11.6 مره من التجفيف بالهواء الساخن علي درجات حرارة المختلفة (50 و60 م°علي التوالي). بالإضافة إلى ذلك، أدى التجفيف بالنافذة الانعكاسية في ظل هذه ظروف إلى قيم أعلى لنسبة التشرب والكثافة الظاهرية والذوبان والرطوبة مقارنة بالقيم المقابلة لمسحوق الجوافة الناتج عن التجفيف بالهواء الساخن (علي 60 م° لمدة 480 دقيقة). وبشكل عام، أدت عملية التجفيف بالنافذة الانعكاسية إلى احتفاظ كبير جدا بحمض الأسكوربيك (فيتامين سي)، والبولي فينولات والفلافونويدات الكلية والمواد المضادة للأكسدة.

الكلمات الاسترشادية: مسحوق الجوافة، التجفيف بالنافذة الانعكاسية، التجفيف بالهواء الساخن، حركية التجفيف، الخواص الفيزيائية والكيميائية، اللون، المركبات المضادة للأكسدة، التقييم الاقتصادي.