

Effect of drying methods and storage packages on some Stevia varieties quality traits

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ABSTRACT:

Stevia plant have sweetening complex glycosides that have a potential 250–300 times that of sucrose in addition to its no calories action let it suitable for diabetic and dietary habits. Laboratory experiments were conducted to estimate the effect of drying methods and storage containers for the leaves of three types of Stevia plants in the laboratory of the Sugar Crops Research Institute at the Agricultural Research Center, Egypt in the 2023 season, to evaluate some quality traits of the leaves of some Stevia varieties (Egy1, Spanti and China1). The leaves were dried using three drying methods (microwave oven, electric oven and air drying) and were divided into four storage packages (plastic, under vacuum, jute and paper). All treatments were stored and the results were estimated after 90, 180 and 270 days from the start of storage the determinant traits were measured with Fourier Transform Infrared Spectroscopy (FTIR). Results reveal that all studied traits were significantly affected with drying methods and storage package of the three studied varieties. The results indicated that drying Egy1 Stevia variety leaves in microwave or electric oven with plastic vacuum packing or jute gave the best values for all studied traits followed by Spanti then China 1 varieties for all storage periods.

Keywords: Stevia; storage package; drying method; stevioside; FTIR analysis.

INTRODUCTION

Nowadays, rapid changes in dietary habits, especially an increase in sugar consumption are the basic cause of human diseases like obesity, diabetes, tooth decay and cardiovascular diseases hence, utilization of natural sweetening agents other than sugar has been initiated around the world and more than 20 sweeteners are being used according to the priority and availability. *Stevia rebaudiana* Bertoni has attracted many researchers because its non-toxic and non-mutagenic nature with no calorie glycosides Stevia has also many medicinal uses including diabetic foods, weight loss programs, hypertension treatment and blood pressure control, toothpaste, mouth washes- plaque retardants, skincare, eczema and acne control, rapid healing agent and bacterial agent. (Singh and Reo 2005). Despite the presence of several sweetening compounds, Stevioside is the main sweetening agent in the plant. Being an ideal natural product to replace sugar, (Paul et al 2012)

Stevia rebaudiana Bertoni is one of 154 members of Stevia genus, native to valley Rio Mondaryn high lands of Paraguay (between 25-26 degrees south latitude) where it grows in sandy soils near streams. Stevia is a small perennial herb shrub with green leaves the sweet component of the plant is 200-300 times sweeter than sucrose has similar tasteful properties (Midmore and Rank 2002). Stevia

plant was introduced to Egypt in 1990 as a source of natural sweet product with low energy. Stevia has many advantages to be used in Egypt since succeed in poor lands and it has a moderate water and low fertilization needs also its high potential for yield under warm climates. (Allam et al 2001).

Drying process is to eliminate moisture and leads to a reduction of the visual, organoleptic and functional characteristics of the Stevia plants, which negatively affects its final quality traits like color, texture, aroma, essential oil content and shape (Curevo et al 2012). Drying at temperatures of 50 – 60 °C was an effective method in removing moisture content of Stevia plants. The quality of dried leaves produced in terms of color, sweetness and nutrient content was better compared with drying at 70 °C (Samsudin and Aziz et al 2013). In fact the chemical composition of dry leaves was more influenced by the varieties than different drying methods (Khalil et al 2015). Where increase in the content of seven of the sweeteners, excluding steviol bioside, was found at drying temperature up to 50 °C (Lemus-Mondaca et al 2015). Stevia has good productivity under Egypt conditions. It's planted during March and gives four cuts annually by ranging from 1.698 to 2.606 ton/fed dry leaves with ratio of stevioside (St) content from 6.72 to 8.67% and rebaudioside-A from 4.23 to 8.67% according to variety. China1 variety surpassed the other two varieties in

fresh and dry weight of leaves g/plant, followed by Spanti and Egy1 varieties respectively (Khalil *et al* 2016). Where phenolics and flavonoids showed the highest value at drying temperature 40 °C (Lemus -Mondaca *et al* 2016) using different drying methods microwave drying, the particles were even, regular, and compact while the sun- and oven dried particles resembled angular bricks. (Gasmalla *et al* 2017). Stevia varieties were significantly different in all studied yield characters. China1 varieties gave the highest values of stevioside% , rebaudioside-A%, rebaudioside-A for dry leaves where Egy1 varieties gave the highest values in the first and second seasons (Kenawy 2018). Indirect solar (900w) drying was observed to have superior conditions analyzed solar drying technologies will allow to obtain important savings of conventional energy with a smaller environmental impact and a better quality of the final product in relation to the traditional methods of drying (Tellez *et al* 2018) Vacuum packaging of foods offers several distinct advantages for the food industry, mainly associated with the reduction, or even the potential elimination, of atmospheric oxygen. This slows the rate of oxidative reactions and limits the growth of aerobic bacteria and fungi (Dominguez *et al* 2021). Far-infrared drying technology could increase the number of micropores on the surface and inside the materials and improve the quality of dried products (Huang *et al* 2021). Packaging material, storage period, storage condition and drying method had a significant effect on the different quality traits and shelf life of Stevia leaves (Gagandeep *et al* 2022). The glass jars were the best packaging material followed by jars. Stevia stored in dried leaves retained better quality characteristics in comparison to Stevia stored in powdered form during nine months of storage (Gagandeep *et al* 2024). Consequently, those studies aimed to investigate the effect of drying methods and storage packages on some Stevia varieties quality traits.

MATERIALS AND METHODS

Laboratory experiments were conducted to estimate the effect of drying methods and storage containers for the leaves of three varieties of Stevia plants in the laboratory of the Sugar Crops Research Center at the Agricultural Research Center in the 2022-2023 season.

Studied factors:

The experiment consisted of 36 treatment combinations involving three factors as detailed below

Factor I Varieties (V)

V1: Egy1 (Genotype).

V2: Spanti.

V3: China 1.

Factor II Drying methods (D)

D1: Microwave oven (tmd-25sk-bk 25 liter 900 w with 5lev. 513x306x429 dim).

D2: Electric oven (Guohua 27-2 380x350x350mm, 500w).

D3: Air drying.

Factor III: Storage packages (P)

P1: Plastic package of low density poly ((LDPE) 150x200 mm).

P2: Vacuum package of nylon-polyethylene laminates.

P3: Jute package.

P4: Paper package made of 70 grams of unlighted kraft paper 150*200mm.

FTIR (Nicolet 380 IEC/EN680825-I/A2:2001).

Method: The Fourier-transform infrared spectroscopy (FTIR) instrument sends infrared radiation of about 10,000 to 100 cm⁻¹ through a sample, with some radiation absorbed and some passed through. The absorbed radiation is converted into rotational and/or vibrational energy by the sample molecules. The resulting signal at the detector presents as a spectrum, typically from 4000 cm⁻¹ to 400cm⁻¹, representing a molecular fingerprint of the sample. Each molecule or chemical structure will produce a unique spectral fingerprint (Bacsik *et al* 2004)

Three varieties of *Stevia rebaudiana* Bertoni named Egy1, Spanti and China 1 obtained from the Sugar Crops Research Institute (SCRI) at Agriculture Research Center (ARC), Egypt, Stevia varieties were planted and harvested during season 2002-2023 in the experimental fields of (SCRI) in Giza governorate. The plants were cut after 4 months of cultivation on (1st cut). The leaves of three varieties were air dried 72 hour in shaded place.

The primary airily dry leaves dried with three drying methods (D)(air drying in room in shaded place and by electric oven at 55° C for three day till the weight is steeled and by microwave oven at 900w for 4 min). Packed in different kind of packages (P) (plastic package,

vacuum package, jute package and paper package) as stored at constant temperature (5°C) and results were recorded after 90, 180, 270 days from storing date.

The studied chemical traits (moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage) was determined by Fourier-transform infrared spectroscopy (FTIR) in chemical laboratory of central laboratories of Cairo University as in characterized extract of Stevia with different methods by spectroscopic (Ravinder and Ajay 2015), The FT-IR technique confirmed that SGs maintained 13 their chemical integrity during the applied drying processes. The spray dried SGs products presented the best physicochemical characteristics and the most appealing sensorial ones. (Chranioti *et al* 2016).

The experiments were laid out in a completely split-split-plot design with three replications for each with a weight of one kilogram for the replicate where varieties was the main factor and drying method was the sub factor and storing packages was the sub-sub factor (Little and Hills 1978). Data were statistically analyzed according to the technique of analysis of variance (ANOVA) and the least Significant Difference (LSD) method was used to test the difference among the treatment means as published by (Gomez and Gomez 1984).

RESULTES AND DISCUSSION

After 90 days from storing date

Stevia leaves moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage affected by drying methods and storage packages of some Stevia varieties after 90 days from storage in season 2022/2023 in Table (1).

Results recorded in Table 1 showed clearly that moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage of leaves are significantly affected by both drying method and storage packages some Stevia varieties after 90 days from storage date in season 2022/2023.

Drying methods (D)

Results showed that moisture percentage total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage of leaves are significantly affected by drying methods (D).

Stevia leaves dried by microwave method (D1) gave the best total reducing sugar, carbohydrate, stevioside percentage and rebaudioside-A percentage with values of 11.36, 51.01, 26.43 and 13.49% respectively On the other hand Stevia leaves dried by air method (D3) gave the worst moisture percentage, total reducing sugar, carbohydrate, stevioside percentage and rebaudioside-A percentage with values of 5.27, 10.5, 49.66, 26.24 and 13.03% respectively where Stevia leaves dried by electric oven method (D2) gave the best moisture percentage, with value of 4.81%.

Positive effect of drying methods on Stevia leaves quality traits may be due to decrease moisture percentage and its impact on increase these trait, with addition to positive effect of microwave methods increasing leaves quality traits compared with the others methods (air and electric oven methods). These results is in harmony with Curevo *et al* 2012, Samsudin and Aziz 2013, Lemus -Mondaca *et al* 2015, Lemus -Mondaca *et al* 2016, Gasamalla *et al* 2017 and Tellez *et al* 2018.

Stevia varieties (V)

Results showed that Stevia varieties (V) significant responded for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage in season 2022/2023

Stevia leaves of variety Egi 1 (V1) recorded the best value for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage as 3.85, 13.98, 64.20, 33.95 and 16.74% respectively. Where Stevia leaves of variety China 1 (V3) recorded the worst value for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage with values 6.02, 7.51, 35.18, 18.36 and 9.24% respectively.

The results recorded that Egi 1 (V1) Stevia variety gave superiority in responding to study factors due to the differences between genotypes factors of varieties and it's integrated with environmental conditions. These results were in harmony with Khalil *et al* 2015, Khalil *et al* 2016 and Kenawy 2018.

Storage packages (P)

Results showed that moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage of leaves are significantly affected by storage packages (P).

Stevia leaves stored in vacuum packages (P2) gave the best values for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage as 3.26, 11.91, 51.20, 26.52 and 13.10% respectively while Stevia leaves stored in paper packages (P4) gave highest moisture percentage with value of 6.22. Where gave the lowest Total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage with values of 10.29, 49.79, 26.16 and 12.64% respectively.

Results showed that vacuum package gave inhabitations for growth of aerobic spoilage micro-organisms and reduces the rate of oxidative deterioration which affect all other traits that was in harmony with Dominguez *et al* 2021, Huang *et al* 2021, Nejad *et al* 2021, Gagandeep *et al* 2022 and Gagandeep *et al* 2024.

Interactions:

Interaction between storage packages (P) and Stevia varieties (V)

Results showed that Stevia varieties (V) significantly difference in moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A. affected by storage packages (P).

Stevia leaves stored in vacuum packages of variety Egy 1 (V1P2) gave that the best values for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage as 1.99, 14.62, 65.08, 34.86 and 17.16% respectively while Stevia leaves stored in vacuum package of variety China 1 (V3P4) gave that the highest with value of 7.22%. Where Stevia leaves stored in paper packages of variety China 1 (V3P4) gave the lowest of most studied traits 6.72, 34.68, 17.35 and 8.87% respectively.

Interaction between drying methods (D) and Stevia varieties (V)

Results showed that Stevia varieties (V) significantly difference of moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage affected by drying methods (D).

Stevia leaves dried by microwave method of variety Egy 1 (V1D1) gave the best values of moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage with as 3.65, 14.37, 64.81, 34.81 and 17.21% respectively and Stevia leaves dried by air method of variety China 1

(V3D3) gave the highest moisture percentage with value of 6.28%. Where Stevia leaves dried by air method of variety China 1 (V3D3) gave the lowest total values for most studied traits 7.49, 34.15, 16.92 and 8.29% respectively.

Interaction between storage packages (P) and drying methods (D)

Results showed that moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage of leaves are significantly affected by drying methods (D) and storage packages (P)

Stevia leaves dried by microwave method and stored in vacuum packages (D1P2) recorded the best value for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage as, 11.94, 52.05, 26.68 and 13.34% respectively while Stevia leaves dried by air method while stored in paper packages (D3P4) gave the highest moisture percentage with value of 6.78%. Where Stevia leaves dried by air method and stored in paper packages (D3P4) recorded the lowest values for most studied traits as 9.74, 49.09, 26.08 and 12.07% respectively

Interaction between storage packages (P), drying methods (D) and Stevia varieties (V)

Results showed that Stevia varieties (V) significantly different for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage .affected by drying methods (D), storage packages (P).

Stevia leaves dried by microwave method and stored vacuum package of variety Egy 1 (V1D1P2) gave the best values for moisture percentage, Total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage with values of 1.86, 15.01, 65.08, 36.18 and 17.99% respectively, while Stevia leaves dried by air method and stored paper package of variety China 1 (V3D3P4) gave the highest moisture percentage with value of 7.55%. Where Stevia leaves dried by air method and stored paper package of variety China 1 (V3D3P4) the lowest values for most studied traits as 5.33, 32.89, 16.56 and 8.05% respectively.

After 180 days from storing date

Stevia leaves moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage affected by drying methods and storage

packages of some Stevia varieties after 180 days from storage in season 2022/2023 in table (2).

Results recorded in Table 2 clearly showed that moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside A percentage of leaves are significantly different affected by both drying method and storage packages some Stevia varieties in season 2022/2023.

Drying methods (D)

Results showed that moisture percentage total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage of leaves are significantly different affected by drying methods (D).

Stevia leaves dried by microwave method (D1) recorded best values for moisture percentage, total reducing sugar, carbohydrate, stevioside percentage and rebaudioside-A percentage with values of 3.86, 9.59, 45.54, 24.12 and 12.06% respectively, while Stevia leaves dried by air method (D3) gave the highest moisture percentage with value of 4.38%. Otherwise Stevia leaves dried by air method (D3) gave the lowest values for most studied traits as 9.13, 44.58, 23.52 and 11.26%, respectively. These results may be due to decrease moisture content in leaves that led to improving Stevia quality traits, especially at leaves drying in microwave compared with air drying or oven drying. These results in similar with Curevo *et al* 2012, Samsudin and Aziz 2013, Lemus -Mondaca *et al* 2015, Lemus -Mondaca *et al* 2016, Gasamalla *et al* 2017 and Tellez *et al* 2018.

Stevia varieties (V)

The results presented in Table (2) showed that Stevia varieties (V) responded significantly for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage.

Stevia leaves variety Egy 1(V1) recorded the best values for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage while rebaudioside-A percentage with values of 3.13, 13.24, 56.98, 29.16 and 14.3% respectively. While Stevia leaves of variety China 1 (V3) recorded the highest moisture percentage with value of 5.40%. Where Stevia leaves of variety China 1 (V3) recorded the lowest values for most studied traits as 6.57, 32.62, 18.2, and 8.39% respectively, these results may be attributed to the difference between genotypes factors of varieties and it's integrated with

environmental conditions. These results were in harmony with Khalil *et al* 2015, Khalil *et al* 2016 and Kenawy 2018.

Storage packages (P)

Results showed that moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage of leaves are significantly difference affected by storage packages (P).

Stevia leaves stored in vacuum packages (P2) gave the best values for moisture percentage, Total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage as 2.51, 10.42, 46.29, 23.86% and 11.66% respectively while Stevia leaves stored in paper packages (P4) gave the highest moisture percentage with value of 4.92%. Otherwise Stevia leaves stored in paper packages (P4) gave the lowest values for other studied traits as 9.33, 44.19, 23.21 and 10.58% respectively. Results showed that vacuum package inhibits the growth of aerobic spoilage micro-organisms and reduces the rate of oxidative deterioration which affect all other traits that was in harmony with Dominguez *et al* 2021, Huang *et al* 2021, Nejad *et al* 2021, Gagandeep *et al* 2022 and Gagandeep *et al* 2024.

Interactions:

Interaction between Storage package (P) and Varieties (V)

Results showed that Stevia varieties (V) significantly difference in moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A affected by storage packages (P).

Stevia leaves stored in vacuum packages of variety Egy 1(V1P2) gave the best values for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage 1.45, 13.94, 58.89, 29.97 and 14.73% respectively and Stevia leaves stored in vacuum package of variety China 1(V3P4) recorded that the highest moisture percentage with value of 6.02%. Where Stevia leaves stored in paper packages of variety China 1 (V3P4) gave the lowest values for most studied traits as 5.56, 31.64, 16.94 and 7.67% respectively.

Interaction between drying methods (D) and Stevia varieties (V)

Results showed that Stevia varieties (V) significantly difference in moisture percentage, total reducing sugar, total carbohydrate,

stevioside percentage and rebaudioside-A affected by drying methods (D).

Stevia leaves dried by microwave method of variety Egy 1 (V1D1) gave the best values for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage 3.13, 13.59, 58.67, 30.28 and 14.94% respectively while Stevia leaves dried by air method of variety China 1 (V3D3) gave the highest moisture percentage with value of 5.14%. Where Stevia leaves dried by air method of variety China 1 (V3D3) gave lowest values for most studied traits as 6.27, 31.95, and 17.98 while 7.86% respectively.

Interaction between storage package (P) and drying methods (D)

Results showed that moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage of leaves are significantly different affected by drying methods (D) and storage packages (P).

Stevia leaves dried by microwave method and stored in vacuum packages (D1P2) gave the best values for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage 2.20, 10.63, 46.55, 24.22 and 12.10% respectively and Stevia leaves dried by air method while stored in paper packages (D3P4) gave the highest moisture percentage with value of 5.22%. Where Stevia leaves dried by air method and stored in paper packages (D3P4) gave lowest values for most studied traits as 8.23, 43.60, 22.68 and 10.03% respectively.

Interaction between storage package (P), drying methods (D) and Stevia varieties (V)

Results showed that Stevia varieties (V) significantly difference moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A affected by drying methods (D) and storage packages (P).

Stevia leaves dried by microwave method and stored vacuum package of variety Egy 1 (V1D1P2) gave the best values for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage 1.23, 14.01, 60.22, 30.92 and 15.46% while Stevia leaves dried by air method and stored paper package of variety China 1 (V3D3P4) gave the highest moisture percentage with value of 6.32%. Where Stevia leaves dried by air method and stored paper package of variety China 1 (V3D3P4) gave lowest values for most studied

traits as 5.13, 30.89, 16.26 and 7.03% respectively.

After 270 days from storing date

Stevia leaves moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage affected by drying methods and storage packages of some Stevia varieties in season 2022/2023 are given in Table (3).

Results recorded in Table 3 showed clearly that moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage of leaves are significantly affected by both drying method and storage packages some Stevia varieties after 270 days from storing date in season 2022/2023.

Drying methods (D)

Results showed that moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage of leaves are significantly affected by drying methods (D).

Stevia leaves dried by microwave method (D1) gave the best values for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage 3.13, 7.73, 40.24, 22.16 and 11.28% respectively while Stevia leaves dried by air method (D3) gave the highest moisture percentage with value of 4.19%. Where Stevia leaves dried by air method (D3) gave lowest values for most studied traits 7.01, 38.98, 20.83 and 10.41% respectively. These results may be due to decrease in Stevia leaves moisture percentage led to increase in all quality traits under the study especially drying in microwave oven compared with the other drying two. These results are in harmony with Curevo *et al* 2012, Samsudin and Aziz 2013, Lemus -Mondaca *et al* 2015, Lemus -Mondaca *et al* 2016, Gasamalla *et al* 2017 and Tellez *et al* 2018.

Stevia varieties (V)

Results showed that Stevia varieties (V) responded significantly for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage.

Stevia leaves variety Egy 1 (V1) recorded the best response for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage with values of 2.48, 11.63, 51.82, 26.82 and 12.22% respectively while Stevia leaves of

variety China 1 (V3) gave the highest response for moisture percentage with value of 4.54%. Where Stevia leaves of variety China 1 (V3) recorded the lowest response for total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage with values 5.00, 28.68, 15.44 and 7.79% respectively. These results may be attributed to the difference between genotype factors and it's integrated with environmental conditions. These results were in harmony with Khalil *et al* 2015, Khalil *et al* 2016 and Kenawy 2018.

Storage packages (P)

Results showed that moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage of leaves are significantly difference affected by storage packages (P).

Stevia leaves stored in vacuum packages (P2) gave the best values for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage 2.23, 8.30, 41.56, 22.24 and 10.89% respectively while Stevia leaves stored in plastic packages (P1) gave the highest moisture percentage with value of 4.14. Where Stevia leaves stored in paper packages (P4) gave the lowest values of most studied traits 6.53, 38.40, 21.25 and 10.08% respectively. Results showed that vacuum package inhibits the growth of aerobic spoilage micro-organisms and reduces the rate of oxidative deterioration which affect all other traits that was in harmony with Dominguez *et al* 2021 , Huang *et al* 2021, Nejad *et al* 2021 , Gagandeep *et al* 2022 and Gagandeep *et al* 2024.

Interactions:

Interaction between storage package (P) and Stevia varieties (V)

Results showed that Stevia varieties (V) significantly difference moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A affected by storage packages (P).

Stevia leaves stored in vacuum package of variety Egy 1(V1P2) gave the best values for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage with values of 1.13, 12.72, 53.79, 27.48 and 12.94% respectively while Stevia leaves stored in vacuum package of variety China 1(V3P4) gave that the highest moisture percentage with value of 5.46%. Where Stevia leaves stored in paper packages of variety China 1 (V3P4) gave the lowest

values for most studied traits 4.29, 27.99, 14.6 and 7.35% respectively.

Interaction between drying methods (D) and Stevia varieties (V)

Results showed that Stevia varieties (V) significantly difference moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A affected by drying methods (D).

Stevia leaves dried by microwave method of variety Egy 1 (V1D1) gave the best values for moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage with values of 2.00, 11.82, 52.32, 27.39 and 12.96% respectively while Stevia leaves dried by air method of variety China 1 (V3D3) gave the highest moisture percentage with value of 5.31. Where Stevia leaves dried by air method of variety China 1 (V3D3) gave the lowest values for most studied traits 4.49, 27.53, 14.59 and 7.17% respectively.

Interaction between storage package (P) and drying methods (D)

Results showed that moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage of leaves are significantly different affected by drying methods (D) and storage packages (P).

Stevia leaves dried by microwave method and stored in vacuum packages (D1P2) gave the highest total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage with value of 8.71, 41.99, 22.81 and 11.16% respectively while Stevia leaves dried by air method and stored in plastic packages (D3P1) gave the highest moisture percentage with value of 4.97%. Where Stevia leaves dried by air method and stored in paper packages (D3P4) gave the lowest values for most studied 6.18, 37.49, 20.49 and 9.54% respectively.

Interaction between storage packages (P), drying methods (D) and Stevia varieties (V)

Results showed that Stevia varieties (V) significantly difference moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A affected by drying methods (D) and storage packages (P).

Stevia leaves dried by microwave method and stored vacuum package of variety Egy 1 (V1D1P2) gave the best values for moisture percentage, total reducing sugar, total

carbohydrate, stevioside percentage and rebaudioside-A percentage 1.04, 13.01, 54.01, 27.93 and 13.82% while Stevia leaves dried by air method and stored paper package of variety China 1 (V3D3P4) gave the highest moisture percentage with value of 6.08. Where Stevia leaves dried by air method and stored paper package of variety China 1 (V3D3P4) gave the lowest values for most studied 3.91, 26.94, 13.83 and 6.72% respectively.

Generally these results suggested that combined of leaves dried with microwave and stored in vacuum package of variety (Egy 1) (V1D1P2) led to increase in the studied desirable characters in compared with the other treatments. The research subject that treatment of (D1P2) had to be apply to Stevia stored leave in all studied varieties (V1, V2 V3) to increase the chemical quality under experiment conditions.

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Al-Az **Table 1:** Effect of drying methods and storage packages of some stevia varieties on leaves moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside A percentage after 90 days from storage

Storing Periods ^a		Moisture percentage				Total reducing sugar				Total Carbohydrate				Stevioside percentage				Rebaudioside A percentage			
Varieties (V)	Storage packages	Drying methods (D)				Drying methods (D)				Drying methods (D)				Drying methods (D)				Drying methods (D)			
		Microw ave (D1)	Oven (D2)	Air (D3)	Mean	Microw ave (D1)	Oven (D2)	Air (D3)	Mean	Microw ave (D1)	Oven (D2)	Air (D3)	Mean	Microw ave (D1)	Oven (D2)	Air (D3)	Mean	Microw ave (D1)	Oven (D2)	Air (D3)	Mean
Egy 1 (V1)	Plastic (P1)	4.41	4.36	5.23	4.67	14.69	14.22	13.59	14.17	64.93	64.73	63.37	64.34	34.87	33.78	33.64	34.1	17.35	16.86	16.75	16.99
	Vacuum(P2)	1.86	2.12	1.98	1.99	15.01	14.53	14.33	14.62	65.8	65.32	64.12	65.08	36.18	34.41	33.99	34.86	17.99	17	16.5	17.16
	Jute (P3)	3.56	3.89	3.82	3.76	14.56	14.11	13.23	13.97	64.63	64.35	63.15	64.04	34.09	33.49	32.77	33.45	17.04	16.65	16.19	16.63
	Paper (P4)	4.78	4.87	5.35	5	13.2	13.68	12.66	13.18	63.87	63.12	62.99	63.33	34.08	33.38	32.69	33.38	16.44	16.31	15.79	16.18
	Mean	3.65	3.81	4.1	3.85	14.37	14.14	13.45	13.98	64.81	64.38	63.41	64.2	34.81	33.77	33.27	33.95	17.21	16.71	16.31	16.74
Spanti (V2)	Plastic (P1)	6.51	5.46	7.33	6.43	11.7	11.52	11.63	11.62	54.78	53.36	48.69	52.28	28.86	27.73	23.94	26.84	14.03	13.61	12.41	13.35
	Vacuum(P2)	3.86	3.32	4.01	3.73	12.16	12.63	12	12.26	54.26	53.46	49.23	52.32	29.83	28.02	24.85	27.57	14.43	13.86	12.97	13.75
	Jute (P3)	5.26	4.02	2.92	4.07	11.53	11.33	11.42	11.43	53.99	53.14	48.16	51.76	28.19	27.75	23.35	26.43	14.1	13.17	12.18	13.15
	Paper (P4)	5.88	5.97	7.45	6.43	10.6	11.12	11.23	10.98	53.89	52.71	47.14	51.25	28.07	27.22	22.82	26.04	14.42	12	11.42	12.61
	Mean	5.38	4.69	5.43	5.17	11.5	11.65	11.57	11.57	54.23	53.17	48.31	51.9	28.74	27.68	23.74	26.72	14.25	13.16	12.25	13.22
China1 (V3)	Plastic (P1)	6.61	6.36	7.43	6.8	8.23	7.89	6.89	7.34	37.01	34.46	33.69	34.79	20.12	18.25	17.01	18.46	10.56	9.13	8.34	9.34
	Vacuum(P2)	4.01	4.22	4.01	4.08	8.94	8.65	8.95	8.85	37.56	35.27	35.16	35.36	21.71	18.95	17.43	19.36	10.96	9.28	8.57	9.6
	Jute (P3)	5.76	6.04	6.12	5.97	7.99	7.63	5.77	7.13	36.78	35.68	33.25	35.87	20.1	18	16.68	18.26	10.16	9.1	8.19	9.15
	Paper (P4)	6.98	7.12	7.55	7.22	7.68	7.16	5.33	6.72	35.46	34.9	32.89	34.68	17.82	17.67	16.56	17.35	9.71	8.84	8.05	8.87
	Mean	5.84	5.94	6.28	6.02	8.21	7.83	7.49	7.51	36.29	35.09	34.15	35.18	19.94	18.22	16.92	18.36	10.35	9.09	8.29	9.24
Storage package (P)	Plastic (P1)	5.84	5.39	6.66	5.96	11.21	11.54	10.37	11.04	51.03	50.66	50.31	50.67	25.54	26.36	26.12	26.01	13.25	13.01	12.41	12.89
	Vacuum(P2)	3.24	3.22	3.33	3.26	11.94	12.04	11.76	11.91	52.05	51.47	50.08	51.2	26.68	26.42	26.45	26.52	13.34	13.13	12.82	13.1
	Jute (P3)	4.86	4.65	4.29	4.6	11.02	11.36	10.14	10.84	50.72	50.59	50.15	50.49	26.51	26.26	26.68	26.48	13.13	12.96	12.26	12.78
	Paper (P4)	5.88	5.99	6.78	6.22	10.65	10.49	9.74	10.29	50.22	50.05	49.09	49.79	26.23	26.17	26.08	26.16	13.04	12.81	12.07	12.64
Drying methods (D)		4.96	4.81	5.27		11.36	11.21	10.5		51.01	50.69	49.66		26.43	26.33	26.24		13.49	13.18	13.03	
LSD at		LSD 0.05				LSD 0.05				LSD 0.05				LSD 0.05				LSD 0.05			
Varieties (V)		0.01				0.01				0.1				0.05				0.03			
Storage packages (P)		0.01				0.01				0.11				0.06				0.03			
V X P		0.02				0.02				0.2				0.1				0.05			
Drying methods (D)		0.01				0.01				0.11				0.06				0.03			
V X D		0.02				0.02				0.2				0.1				0.05			
P X D		0.02				0.02				0.23				0.12				0.06			
V X P X D		0.04				0.04				0.4				0.21				0.1			

Table 2: Effect of drying methods and storage packageages of some stevia varieties on leaves moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside A percentage after 180 days from storage

Storing Periods ^a		Moisture percentage				Total reducing sugar				Total Carbohydrate				Stevioside percentage				Rebaudioside A percentage			
Varieties (V)	Storage packages	Drying method			Mean	Drying method			Mean	Drying method			Mean	Drying method			Mean	Drying method			Mean
		Microw ave (D1)	Oven (D2)	Air (D3)		Microw ave (D1)	Oven (D2)	Air (D3)		Microw ave (D1)	Oven (D2)	Air (D3)		Microw ave (D1)	Oven (D2)	Air (D3)		Microw ave (D1)	Oven (D2)	Air (D3)	
Egy 1 (V1)	Plastic (P1)	3.45	3.45	3.89	3.6	13.72	13.26	13.32	13.43	58.76	57.63	54.69	57.03	30.05	29.46	27.57	29.03	15.15	14.64	14.11	14.63
	Vacuum(P2)	1.23	1.23	1.89	1.45	14.01	13.96	13.84	13.94	60.22	58.99	57.46	58.89	30.92	29.99	29	29.97	15.46	14.99	13.74	14.73
	Jute (P3)	3.56	3.56	3.56	3.56	13.63	13.02	13.25	13.3	58.02	56.99	54.37	56.46	30.29	29.27	27.62	29.06	14.92	14.45	13.18	14.18
	Paper (P4)	3.8	3.8	4.12	3.91	12.99	11.9	11.98	12.29	57.66	55.68	53.26	55.53	29.85	28.31	27.57	28.58	14.23	13.83	12.9	13.65
	Mean	3.01	3.01	3.37	3.13	13.59	13.04	13.1	13.24	58.67	57.32	54.95	56.98	30.28	29.26	27.94	29.16	14.94	14.48	13.48	14.3
Spanti (V2)	Plastic (P1)	4.55	4.36	4.99	4.63	7.07	8.36	8.77	8.07	45.12	45.01	44.64	44.92	24.94	24.72	23.53	24.4	12.07	11.46	10.83	11.45
	Vacuum(P2)	2.33	2.1	2.99	2.47	9.01	9.65	10.16	9.61	46.38	45.86	45.66	45.97	25.43	24.53	23.78	24.58	12.36	12.47	11.77	12.2
	Jute (P3)	4.66	4	4.66	4.44	6.98	8.21	8.97	8.05	44.56	44.69	44.16	44.47	24.99	24.22	23.59	24.27	11.81	11.15	10.18	11.05
	Paper (P4)	4.9	4.4	5.22	4.84	6.35	7.12	7.96	7.14	43.76	44.2	43.26	43.74	24.91	24.14	23.67	24.24	11.07	10.71	10.01	10.6
	Mean	4.11	3.72	4.47	4.1	7.35	8.34	8.97	8.22	44.96	44.94	44.43	44.78	25.07	24.4	23.64	24.37	11.83	11.45	10.7	11.32
China 1 (V3)	Plastic (P1)	5.65	5.46	5.01	5.37	6.92	6.32	6.4	6.55	34.41	33.35	32.86	33.54	18.46	18.15	17.98	18.2	9.19	8.56	8.11	8.62
	Vacuum(P2)	3.43	3.28	4.09	3.6	7.89	7.9	7.36	7.72	33.89	33.19	32.26	33.11	18.45	18.33	18.03	18.27	9.52	9.07	8.77	9.12
	Jute (P3)	5.76	5.12	5.76	5.55	6.89	6.29	6.2	6.46	32.51	32.26	31.78	32.18	18.38	17.96	17.23	17.86	8.73	8.17	7.54	8.15
	Paper (P4)	6.23	5.5	6.32	6.02	5.89	5.66	5.13	5.56	32.07	31.96	30.89	31.64	17.57	17	16.26	16.94	8.09	7.88	7.03	7.67
	Mean	5.27	4.84	5.3	5.14	6.9	6.54	6.27	6.57	33.22	32.69	31.95	32.62	18.46	18.15	17.98	18.2	8.88	8.42	7.86	8.39
Storage package (P)	Plastic (P1)	4.55	4.42	4.63	4.53	9.67	9.31	9.06	9.35	45.73	45.26	44.42	45.14	24.21	23.45	23.17	23.61	11.96	11.19	10.94	11.36
	Vacuum(P2)	2.33	2.2	2.99	2.51	10.63	10.5	10.13	10.42	46.55	46.46	45.86	46.29	24.22	23.85	23.52	23.86	12.11	11.79	11.07	11.66
	Jute (P3)	4.66	4.23	4.66	4.52	9.7	9.17	8.94	9.27	45.18	45.27	44.45	44.97	24.13	23.24	23.01	23.46	11.47	11.01	10.54	11.01
	Paper (P4)	4.98	4.57	5.22	4.92	8.41	8.36	8.23	8.33	44.69	44.28	43.6	44.19	23.92	23.02	22.68	23.21	11.11	10.6	10.03	10.58
Drying methods (D)	4.13	3.86	4.38		9.59	9.3	9.13		45.54	45.32	44.58		24.12	23.97	23.52		12.06	11.68	11.26		
LSD at	LSD 0.05				LSD 0.05				LSD 0.05				LSD 0.05				LSD 0.05				
Varieties (V)	0.01				0.02				0.09				0.05				0.02				
Storage packages (P)	0.01				0.02				0.1				0.05				0.03				
V X P	0.02				0.04				0.17				0.09				0.05				
Drying methods (D)	0.01				0.02				0.1				0.05				0.03				
V X D	0.02				0.04				0.17				0.09				0.05				
P X D	0.02				0.05				0.2				0.1				0.05				
V X P X D	0.03				0.08				0.2				0.18				0.09				

Al-Azhu **Table 3:** Effect of drying methods and storage packages of some stevia varieties on leaves moisture percentage, total reducing sugar, total carbohydrate, stevioside percentage and rebaudioside-A percentage after 270 days from storage

Storing Periods		Moisture percentage				Total reducing sugar				Total Carbohydrate				Stevioside percentage				Rebaudioside A percentage			
Varieties (V)	Storage packages	Drying method			Mean	Drying method			Mean	Drying method			Mean	Drying method			Mean	Drying method			Mean
		Microw ave (D1)	Oven (D2)	Air (D3)		Microw ave (D1)	Oven (D2)	Air (D3)		Microw ave (D1)	Oven (D2)	Air (D3)		Microw ave (D1)	Oven (D2)	Air (D3)		Microw ave (D1)	Oven (D2)	Air (D3)	
Egy 1 (V1)	Plastic (P1)	2.69	2.36	3.74	2.93	11.66	11.96	11.36	11.66	52.63	52.66	50.33	51.87	27.51	27.13	25.78	26.81	13.16	12.57	11.89	12.54
	Vacuum(P2)	1.12	1.04	1.22	1.13	13.01	12.58	12.56	12.72	54.01	53.39	53.96	53.79	27.93	27.21	27.3	27.48	13.82	12.96	12.05	12.94
	Jute (P3)	2.75	2.22	3.51	2.83	11.59	11.64	11.22	11.48	52.41	52.27	50.12	51.6	27.46	27.09	25.69	26.75	12.73	12.04	11.04	11.94
	Paper (P4)	2.83	2.39	3.86	3.03	11.02	10.7	10.26	10.66	50.23	50.11	49.77	50.04	26.65	26.27	25.83	26.25	12.12	11.54	10.72	11.46
	Mean	2.35	2	3.08	2.48	11.82	11.72	11.35	11.63	52.32	52.11	51.05	51.82	27.39	26.93	26.15	26.82	12.96	12.28	11.43	12.22
Spanti (V2)	Plastic (P1)	3.79	3.46	4.84	4.03	5.87	6.01	5.23	5.7	40.01	39.46	38.56	39.34	22.9	22.04	21.5	22.15	10.05	9.31	8.89	9.42
	Vacuum(P2)	2.22	2.05	2.32	2.2	6.85	6.44	5.98	6.42	40.16	41.69	40.79	40.88	23.26	22.4	21.14	22.27	10.62	9.52	9.07	9.74
	Jute (P3)	3.85	3.32	4.61	3.93	5.69	5.86	5.12		39.56	38.95	37.16	36.98	22.39	21.96	20.86	21.74	9.98	9.13	8.14	9.08
	Paper (P4)	3.01	3.49	4.96	3.82	4.23	5.33	4.36	4.64	38.26	36.89	35.8	38.56	21.79	21.5	20.06	21.12	9.2	8.54	7.93	8.56
	Mean	3.22	3.08	4.18	3.49	5.66	5.91	5.17	5.58	39.5	39.25	38.08	38.94	22.59	21.98	20.89	21.82	9.96	9.13	8.51	9.2
China 1 (V3)	Plastic (P1)	4.89	5.56	5.94	5.46	6	4.99	4.22	5.07	29.87	28.9	27.89	28.89	16.3	16.09	14.99	15.79	8.4	8.03	7.38	7.94
	Vacuum(P2)	3.32	3.24	3.52	3.36	6.26	5.22	5.83	5.77	30.01	29.16	28.03	29.07	16.9	16.62	15.37	16.3	8.99	8.11	7.59	8.23
	Jute (P3)	4.12	4.52	5.71	4.78	5.62	4.96	4.01	4.86	29.49	29.58	27.26	28.78	15.99	15.03	14.15	15.06	8.29	7.59	7	7.63
	Paper (P4)	3	4.59	6.08	4.56	5.01	3.96	3.91	4.29	29.86	27.18	26.94	27.99	15.04	14.92	13.83	14.6	8.12	7.21	6.72	7.35
	Mean	3.83	4.48	5.31	4.54	5.72	4.78	4.49	5	29.81	28.71	27.53	28.68	16.06	15.67	14.59	15.44	8.45	7.74	7.17	7.79
Storage package (P)	Plastic (P1)	3.79	3.79	4.84	4.14	7.84	7.65	6.94	7.48	40.62	40.53	40.45	40.53	22.45	22.03	20.66	21.71	11.01	10.33	10.02	10.45
	Vacuum(P2)	2.22	2.11	2.35	2.23	8.71	8.08	8.12	8.3	41.99	41.55	41.14	41.56	22.81	22.32	21.59	22.24	11.16	10.96	10.54	10.89
	Jute (P3)	3.57	3.35	4.61	3.84	7.63	7.49	6.78	7.3	39.49	39.36	38.24	39.03	22.28	21.89	20.26	21.48	10.75	10.13	9.94	10.27
	Paper (P4)	2.95	3.49	4.97	3.8	6.75	6.66	6.18	6.53	38.72	38.99	37.49	38.4	21.88	21.37	20.49	21.25	10.69	10	9.54	10.08
	Drying methods (D)	3.13	3.19	4.19		7.73	7.47	7.01		40.24	39.982	38.98		22.16	21.9	20.83		11.28	10.95	10.41	
LSD at	LSD 0.05				LSD 0.05				LSD 0.05				LSD 0.05				LSD 0.05				
Varieties (V)	0.01				0.02				0.08				0.04				0.02				
Storage packages (P)	0.01				0.02				0.09				0.05				0.02				
V X P	0.02				0.03				0.16				0.08				0.04				
Drying methods (D)	0.01				0.02				0.09				0.05				0.02				
V X D	0.02				0.03				0.16				0.08				0.04				
P X D	0.02				0.04				0.18				0.1				0.05				
V X P X D	0.03				0.07				0.31				0.17				0.08				

تأثير طرق التجفيف وعبوات التخزين على بعض صفات جودة أصناف الاستيفيا

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الملخص العربي:

يحتوي نبات ستيفيا على جليكوسيدات معقدة تحتوي على نسبة 250-300 مرة من السكر، بالإضافة إلى خلوه من السعرات الحرارية مما يجعله مناسباً للعادات الغذائية ومرض السكري. أجريت تجارب معملية لتقدير تأثير طرق التجفيف وأوعية التخزين لأوراق ثلاثة أنواع من نباتات ستيفيا في معمل معهد بحوث المحاصيل السكرية بمركز البحوث الزراعية بمصر في موسم 2023، لتقييم بعض الصفات النوعية لنبات الاستيفيا. أوراق بعض أصناف ستيفيا (Egy1، Spanti، China1). تم تجفيف الأوراق باستخدام ثلاث طرق تجفيف (فرن الميكروويف، الفرن الكهربائي، والتجفيف بالهواء) وتم تقسيمها في أربع عبوات تخزين (البلاستيك، تحت التفريغ، الجوت والورق). تم تخزين جميع المعاملات وتم تقدير النتائج بعد 90، 180 و 270 يوماً من بداية التخزين وتم قياس صفات الجوده باستخدام جهاز فورييه للطيف بالأشعة تحت الحمراء (FTIR). أظهرت النتائج أن جميع الصفات المدروسة تأثرت معنوياً بطرق التجفيف وعبوات التخزين للأصناف الثلاثة المدروسة. أشارت النتائج إلى أن تجفيف أوراق الصنف Egy1 بالميكروويف أو الفرن الكهربائي مع التغليف تحت تفريغ أو الجوت أعطى أفضل القيم لجميع الصفات المدروسة يليها الصنف Spanti ثم الصنف China 1 لجميع فترات التخزين.

الكلمات الاسترشادية: الاستيفيا، طرق التجفيف، عبوات التخزين، جودة الاوراق، تحليل FTIR.