

Drying of *Stevia* leaves using laboratory and pilot scale dryers

(Pengerangan daun *Stevia* menggunakan pengering makmal dan pengering perintis)

A. Samsudin* and I. Ab. Aziz*

Keywords: *Stevia* leaves, drying characteristics, colour, nutrient content

Abstract

Drying at temperatures of 50 – 60 °C was an effective method in removing moisture content of *Stevia* plants. At this temperature, the quality of dried leaves produced in terms of colour, sweetness and nutrient content was better compared with drying at 70 °C. The drying process took 5 to 6 h using a laboratory dryer and more than 7 h using a pilot scale dryer to reduce the moisture content from 80% to 3 – 5%. A total of 72 – 74% dried leaves were obtained after threshing the final dried samples. The dried leaves had a brighter (L*), greener (a*) and slightly yellow (b*) colour with values of 54, – 3.0 and 9 respectively, when dried at 50 °C compared to samples dried at 60 – 70 °C. Dried *Stevia* leaves contained stevioside and various types of nutrients and minerals. In every 100 g of dried leaves, there were 16 g protein, 65 g carbohydrate, 2,805 mg potassium, 620 mg calcium, 268 mg phosphorous and 16 mg vitamin C. Dried *Stevia* leaves also contained soluble sugars at 5 – 7% brix with pH around 6.

Introduction

Stevia rebaudiana (Bertoni) is a small bush plant native to Paraguay. Its leaves contain approximately 10% steviosides which are intensely sweet compounds (150 to 300 times sweeter than sugar). The leaves have been traditionally used for hundreds of years in Paraguay and Brazil to sweeten local teas, medicines and as a ‘sweet treat’. The steviosides are compounds that can be extracted and used as alternative sweeteners to sugars, of particular benefit to diabetics and those wishing to reduce sugar intake for health reasons (Midmore and Rank 2002). *Stevia* plants grow well in most places including cold climate countries such as Russia, China and Canada. Currently, China and Paraguay are the main producers of steviosides and Japan is the largest consumer in the world (Midmore and Rank 2002).

Production and utilization of *Stevia* plants in Malaysia is still at the initial stages. Research on the varieties selection and agronomic practices for *Stevia* production was started in 2004 by Malaysian Agricultural Research and Development Institute (MARDI) to explore the potential of *Stevia* industry in the country. Currently, 3 varieties of *Stevia* have been evaluated and have shown good potential to be grown commercially, namely, MSR 028, MR 012 and MR 007. They were originally from Canada and produced an estimated cumulative fresh leaf yield of about 10 t/ha (Tan et al. 2008).

Drying is one of the most important activities in postharvest handling of *Stevia*. Freshly harvested *Stevia* leaves contained about 80% moisture content and will deteriorate easily if not properly dried.

*Mechanization and Automation Research Centre, MARDI Headquarters, Serdang, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia

Authors' full names: Samsudin Ahmad and Abd. Aziz Ibrahim

E-mail: samsa@mardi.gov.my

©Malaysian Agricultural Research and Development Institute 2013

Stevia leaves have to be dried within 8 h after harvest in order to retain the high level of sweetness. Hot air drying was recommended to be carried out at 43 °C or sun drying at an ambient condition of less than 60% relative humidity (Hatter 2010). However, drying at higher temperatures is required in order to fasten the drying process. As such, a drying study was conducted on harvested *Stevia* obtained from MARDI experimental plot using laboratory and pilot scale dryers. The experiments were conducted to determine the following various drying parameters for *Stevia* plants:

- The moisture content reduction and drying rate at selected temperature
- The recovery and quality of product

Materials and methods

Sample preparation

Mechanically harvested *Stevia* plants (MR 12) received from the field consisted of leaves, branches and stalks with total lengths of about 15 – 20 cm. They were divided randomly into 2 portions for the drying experiments. Samples prepared for the laboratory drying experiments were packed

in 9 plastic bags each weighing about 1.5 kg, labeled and stored in a cold room (10 °C) to maintain the freshness of the produce. Samples prepared for pilot scale drying were packed in 2 big bags weighing about 15 kg each, labeled and stored in a similar cold room.

Before the drying experiment was conducted, each bag of *Stevia* plants was taken out from the cold room and transferred into a perforated plastic container. The plants were then washed with water to remove dirt, soil, sand and foreign matter. They were then rinsed with water and placed in a spinner for 2 – 3 min to remove the remaining excess water.

Laboratory drying experiment

The laboratory drying study was carried out using a small dryer in a drying chamber measuring 50 cm long, 40 cm wide and 60 cm high. The dryer was equipped with a 2 kW heating element and an axial blower (Figure 1). The drying temperature was controlled by a digital thermostat and the air flow through the produce was regulated at a rate of about 0.25 m/s.

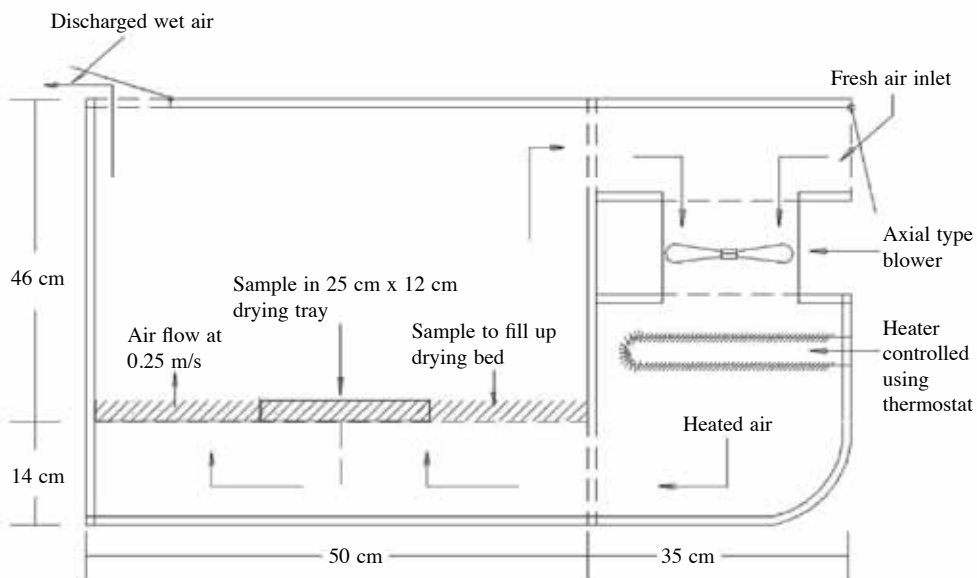


Figure 1. Schematic diagram of laboratory dryer used in the study

A total of 1.2 kg cleaned *Stevia* plants were required for the laboratory drying trial, of which 200 g samples were placed in a drying tray measuring 25 cm x 12 cm and the remaining was placed on a drying bed around the drying tray (*Figure 1* and *Plate 1*). The thickness of sample placed on the drying bed and drying tray was about 5 cm.

The dryer was heated to the required drying temperature and at the same time, *Stevia* required for drying was weighed and prepared for the loading process. When the set temperature was achieved, the produce was loaded to cover the whole drying bed except for the centre part where the drying tray was to be placed. A tray filled with 200 g sample was then placed after the loading process was completed and the drying time was taken starting from that instant. During drying, the weight of sample in the drying tray was measured every 60 min so as to determine the amount of water removed and to estimate the moisture content of produce.

Drying was carried out at 50, 60 and 70 °C within 3 – 6 h depending on the drying temperature. Each temperature was repeated 4 times to get better estimation of the drying rate and moisture reduction. The actual temperatures and relative humidity inside the dryer were measured using the Data Taker Model 605, manufactured by Data Electronics Australia.



Plate 1. Laboratory drying of Stevia plants

The drying process was completed when the produce reached a moisture content of about 2 – 5%. The dried sample was allowed to cool down to room temperature before being packed, sealed in plastic bags and stored in ambient room. On the next day, the sample was threshed to separate the leaves and branches. The leaves were then weighed, packed and labeled for further analysis.

Pilot scale drying experiment

The pilot scale dryer is a cabinet type dryer with a 74 cm long, 58 cm wide and 130 cm high drying chamber. The dryer was equipped with a 0.5 kW axial blower measuring 40 cm diameter, a 5 kW heater and a digital type thermostat to circulate the heated air inside the dryer. The drying chamber was stacked with 10 drying trays each measuring 74 cm x 58 cm.

During the drying trial, about 15 kg of cleaned harvested *Stevia* plants were placed in 10 trays and stacked in the drying cabinet (*Plate 2*). Three small trays measuring 25 cm x 12 cm containing 200 g samples were placed at the centre of the top, middle and bottom trays to estimate the moisture content of samples by determining the weight lost in every h of drying process.

The dryer was first heated for 10 – 15 min to achieve the set temperature before the loading process. The *Stevia* plants were weighed and placed in the 10 drying



Plate 2. Pilot scale drying of Stevia plants

trays. Each tray was loaded with 1.5 kg of produce. When the dryer had achieved the set temperature, the trays were loaded into the drying chamber, the door of the dryer was then closed and the drying process was initiated.

The drying process was carried out at 50 °C and repeated twice to estimate the drying rate and moisture reduction. Actual temperatures and relative humidity inside the dryer were measured using a similar Data Taker Model 605. Drying was carried out for 7 – 9 h until the moisture content of the produce reached about 5 – 8 %. Weight of samples in the small trays was measured and recorded every h as an estimation of moisture content of the produce during drying.

At the end of the drying process, the dried sample was allowed to cool and later weighed and packed into plastic bags. The sample was then threshed to separate leaves and branches. Leaves were weighed, packed and labeled for further analysis.

Moisture content and drying rate

The initial moisture content of *Stevia* was determined using the oven method on 200 g sample randomly taken from every pack of *Stevia* used for laboratory and pilot scale drying experiments. The leaves of the plant were picked manually, cut into small pieces and kept in air tight plastic cups. About 20 g sample was randomly taken for moisture content determination in a drying oven at 105 °C for 24 h (AOAC 1990). The analysis was carried out in 4 replicates to determine the average moisture content which is always expressed as a percentage of wet basis (wb) unless otherwise stated.

The initial moisture content determined was then used to estimate the moisture content of *Stevia* dried using laboratory and pilot scale dryers. The weight loss of sample in the drying tray was used to estimate the drying rate, while the weight of sample in the drying tray was measured and used to estimate moisture content of the sample on each drying stage.

Quality analysis of Stevia leaves

Dried *Stevia* leaves collected from the laboratory and pilot scale drying trials were ground with a blender, packed and labeled separately in 0.08 mm thick polypropylene bags. The colour of fresh and dried *Stevia* leaves was measured using the 'Minolta chromameter CR-200'. The L*, a* and b* values indicated the brightness, greenness and yellowness of the samples. For colour determination, about 60 g samples were placed in 3 petri dishes and measured at three locations along the diameter of the dish.

The soluble sugars determination was done by weighing about 2 g samples of *Stevia* leaves and soaking them in a beaker containing 10 ml distilled water (Chopda and Barrett 2007). Readings were taken using the 'Atago 3810' digital brix meter by placing a few drops of the solution on the cell of the equipment and allowing it to stand for a few seconds until the reading appears. These readings were repeated 6 times to obtain the average value of soluble sugars from each sample.

For pH determination, about 10 g samples were weighed and soaked in a beaker containing 50 ml distilled water (Chopda and Barrett 2007). The samples were stirred and allowed to settle in the water for about 5 min before the readings were taken using the 'Orion Digial pH meter model SA520'. These readings were repeated 6 times to determine the average values from each sample. About 300 g ground *Stevia* collected from a pilot scale drying experiment was packed and labeled for chemical analysis. The sample was sent to the accredited laboratory located in Malaysian Agricultural Research and Development Institute (MARDI) for the determination of nutrient content such as protein, fat, carbohydrate, fibre, minerals and vitamins. In the laboratory, protein, fat and ash were determined using standard AOAC methods (AOAC 1990; 1993). Protein was determined by Kjeldahl nitrogen method using Kjeltec system 1026. Fat was

determined by Soxhlet extraction and ashing was done at 550 °C to constant weight. Crude fibre was determined by Weende method using fibertec system.

Statistical analysis

Statistical analysis was carried out to determine the effective drying temperature of *Stevia* leaves and to study the effect on the quality of the final product. Differences in the moisture content and drying rate of *Stevia* at 3 drying temperatures were compared using the Least Significant Difference (LSD) test. Analysis of variance (ANOVA) and Duncan multiple range test (DMRT) were carried out for L*, a*, b*, pH and brix values of the samples analysed. Six to eight readings were taken to determine the average value of each parameter.

Results and discussion

Moisture reduction

The initial moisture content of washed and cleaned harvested *Stevia* leaves was in the range of 78 – 84%. Using the laboratory dryer, the average drying time to dry the leaves to the final moisture content of 3 – 5%, at 50, 60 and 70 °C with the respective average air relative humidity of 36, 29 and 23% (Table 1) took 6, 5 and 3 h respectively (Figure 2).

During drying, several uncontrollable factors were encountered such as fluctuation of drying air temperatures (2 – 3 °C) due to the changes in the ambient temperatures and relative humidity outside the dryer. The ambient temperatures varied from 29 °C in the morning to 34 °C in the evening while the relative humidity changed from 76 – 60% respectively.

Table 1. Temperature and relative humidity (RH) recorded during drying

Heated air for drying		Ambient	
Temperature (°C)	RH (%) av.	Temperature (°C) av.	RH (%) av.
50	35.9	31.1	67.8
60	28.6	30.6	69.2
70	23.1	30.8	69.4
50*	35.6	32.3	66.3

* Drying using pilot scale dryer

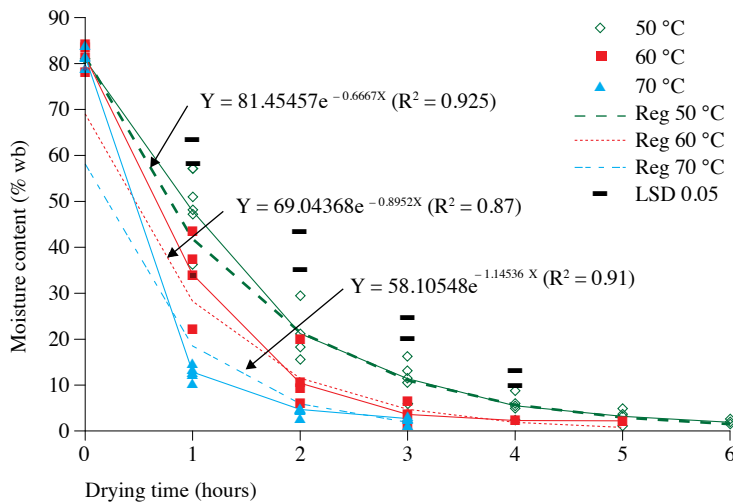


Figure 2. Moisture content reduction of *Stevia* using laboratory dryer

The drying trials were repeated 4 times in order to estimate the average moisture content of *Stevia* at each drying interval. The correlations between moisture content and drying time were then plotted using exponential curves fit as shown in *Figure 2*. There were 3 drying curves developed based on the 3 drying temperatures. The curves clearly separated from each other due to significant moisture content differences (0.05% confidence level) at the initial stage of the drying process. After 4 h drying, the differences were very small and the curves became closer to each other.

The regression equation which relates moisture content and drying time at drying temperature of 50 °C was represented by the exponential equation with $Y = 81.45457 e^{-0.6667X}$ ($R^2 = 0.925$), where Y is the moisture content and x the drying time. This equation fitted well with the R^2 values and can be used to estimate the drying time at selected initial moisture content. Similar

equations were developed for drying at 60 and 70 °C. However, they had different value constants for the regression equations.

Drying curve at 70 °C had the highest value of slope, which indicated that more moisture content was removed per h compared to the other two drying temperatures. At the end of the drying process, the final moisture content of *Stevia* was 2 – 3%. At this value, the *Stevia* leaves can be easily separated from the branches before being packed for further analysis.

Drying rate

The drying rate was measured by determining the rate of moisture removed per h. It was obviously high at the initial stage of drying especially when the drying air temperatures were high. Drying of *Stevia* at 70 °C produced a drying rate of about 157.6 g/h during the first hour of drying (*Figure 3*). It was 10% and 19% higher compared to the drying rates at 50 and 60 °C respectively.

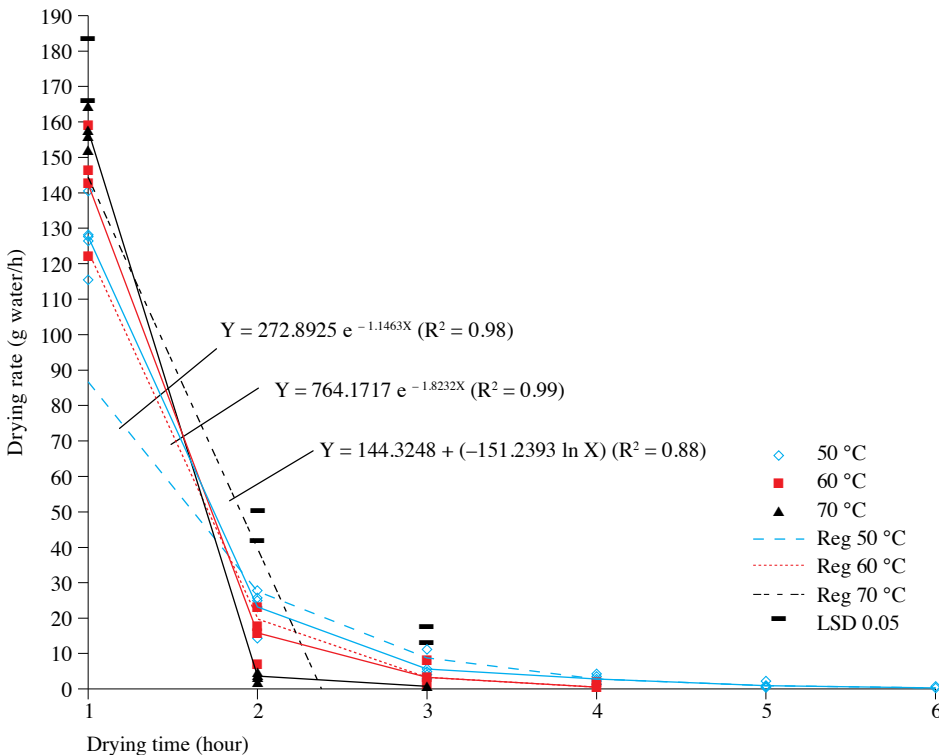


Figure 3. Drying rate of *Stevia* using laboratory dryer

The regression equations which relate drying rate and drying time at 50 °C and 60 °C were represented by the exponential equations of $Y = 272.8925 e^{-1.1463X}$ and $Y = 764.1717 e^{-1.8232X}$ respectively, where Y is the drying rate and X the drying time. This equation was found to fit very well with the R^2 value close to 1. At 70 °C, the relationship between drying rate and drying time is linearly correlated and represented by a logarithmic line with the equation of $Y = 144.3248 + (-151.2393 \ln X)$, where Y is the drying rate and X the drying time.

The straight line equation for drying at 70 °C and exponential equations for drying at 50 and 60 °C indicated that moisture in the *Stevia* leaves was easily removed using heated air. The higher the drying temperature, the faster will be the drying process, however, the quality of produce in terms of physical and chemical contents might be affected. A similar observation was obtained during drying of bay leaves (Demir et al. 2004). Drying at 60 °C with 5% relative humidity took 2.5 h to obtain a product with 10 – 12% moisture content (wet basis). Drying at 50 °C with 15% relative humidity took about 6 h to obtain similar final moisture content. Relationship between moisture content and the drying time fitted several mathematical models including the logarithmic model with a correlation coefficient (r) above 0.95.

Performance of pilot scale drying process

The cabinet type pilot scale dryer with a capacity of 15 kg was used to evaluate the possibility of producing dried *Stevia* leaves for the small scale industry. The capacity of the dryer can be expanded by increasing the size of the drying chamber, blower and heating system. The dryer has 10 trays, each one measuring 74 cm x 58 cm and made of wire mesh bottom to facilitate better air movement through the product. The speed of the air passing through the tray was recorded to be about 0.25 m/s. The rate of air circulation inside the dryer was 8 m³/min where 30% was discharged and 70% was recycled in order to optimize energy usage during drying.

The drying temperature was set at 50 °C and drying process was carried out for 7 h. The actual temperature of the dryer fluctuated between 48 and 54 °C with the air relative humidity at 30 – 45% throughout the drying process. The final moisture content of *Stevia* leaves after drying varied depending on the location of the drying tray. *Stevia* placed at the bottom tray dried faster with a final moisture content of 1.2% while *Stevia* placed in the middle tray had a moisture content of 5.6% and those at the top layer was about 18 – 22% (Figure 4). Further drying was required to have a final moisture content of about 8 – 10%. A similar finding was observed when drying

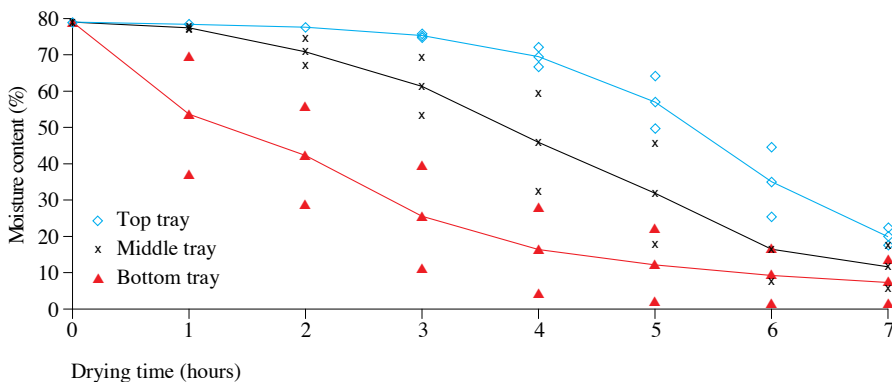


Figure 4. Moisture content reduction of *Stevia* using pilot scale dryer

alfalfa using a re-circulating cabinet dryer (Adapa et al. 2007). The moisture content variation was detected in every tray and the drying had to be extended to about 100 min to get a similar final moisture content. Moving the tray was carried out to get better drying performance.

Recovery of dried leaves

The leaves are the most valuable part of the *Stevia* plant since it contains most of the steviosides and other nutrients. The quantity of leaves recovered after drying was very much dependent on the maturity of the plant and the freshness of the harvested produce. During drying, the leaves are dried together with the stalks and branches. Slight moisture differences between the leaves and branches helped in the threshing process since it will be easier to separate the leaves from the branches.

The quantity of dried leaves collected from the laboratory dryer was in the range of 157 – 181 g. It represented 13 – 15% recovery from the original fresh weight (1.2 kg) or 70 – 75% of the final dried weight (Table 2). The recovery of dried leaves was 72% when the drying process was carried out using the pilot scale dryer. The quantity of dried leaves collected was very much dependent on the quality of plants harvested for drying. Plants which were harvested for the first time had more leaves compared to matured plants that had been harvested several times. A similar condition was observed on coriander plants that had been harvested several times for fresh use and processing (Khan 2009). Drying at 70 °C might have affected the recovery mainly due to over drying which reduced the weight of the end product. This incident was also observed in the drying of kenaf at 80 °C (Samsudin et al. 2004) and chopped oil palm fronds at 100 °C (Samsudin et al. 2005).

Colour changes of dried *Stevia* leaves

Colour was measured to determine the physical properties of the dried *Stevia*

leaves. Most agricultural products will be discolored due to drying and discoloration can be reduced by lowering the drying temperature. The effect of drying on the colour of dried *Stevia* leaves at 3 drying temperatures is illustrated in Table 3.

Fresh leaves had a green colour with average L*, a* and b* values of 48.78 to 49.29, – 13.47 to – 13.62 and 21.23 to 22.01 respectively. Drying changed the leaves significantly towards a brighter, less green and yellowish colour. These colour changes occurred during drying of most of the leaves using conventional or microwave drying process (Shaw et al. 2007). The L*, a* and b* values of dried *Stevia* leaves were in the range of 52.58 to 54.26, – 0.57 to – 2.57 and 5.64 to 8.85 respectively, depending on the drying temperature. Drying at 70 °C most significantly affected the a* and b* values at – 0.57 and 5.64 respectively due to excessive heating, exposing the leaves and rendering them to be less green and more yellowish. A similar observation was made during drying of bay leaves at 60 and 40 °C where two colour differences were observed when measured using the same equipment (Demir et al. 2004).

Brix and pH of dried *Stevia* leaves

The sweet taste of *Stevia* leaves mainly contributed by steviosides can be determined by chemical analysis. Previous analysis showed that *Stevia* planted in MARDI experimental plot contained 4% steviosides and 0.2% rebaudiosides (Rosalizan 2010 – personal communication). The chemical contents were lower compared with plants grown in other countries. Leaves of Paraguayan *Stevia* contains 9 – 13% of the sweet steviosides/rebaudiosides molecules, Chinese *Stevia* contains only 5 – 6% and Indian *Stevia* contains about 9.08% steviosides based on dry weight of leaves (Yadav et al. 2011).

Measurements using the brix meter showed that there was a traceable quantity of soluble sugars in the *Stevia* leaves. About 1.6% of soluble sugars were detected in the

Table 2. Recovery of dried leaves

Drying temperature (°C)	Weight of whole plant after drying (g)	Weight of dried leaves (g)	Recovery of dried leaves (% dry basis)
50	243.8	181.0	74.2a
60	237.7	179.4	75.5a
70	223.3	157.1	70.4b
50*	2,480.0	1790.0	72.2ab

Mean values with different letters in recovery column are significantly different ($p < 0.05$) based on DMRT

Note: Initial weight of *Stevia* for laboratory drying is 1,200 g

Initial weight of *Stevia* for pilot scale drying is 15 kg

*Pilot scale drying trial

Table 3. Effect of drying on colour (L*, a* and b* values) of *Stevia* leaves at 3 drying temperatures

Drying temperature (°C)	Fresh <i>Stevia</i> leaves			Dried <i>Stevia</i> leaves		
	L*	a*	b*	L*	a*	b*
50	49.11	-13.62	21.72	53.88a	-2.57b	8.85d
60	48.78	-13.58	21.23	52.60a	-1.32b	6.80d
70	49.22	-13.47	22.01	52.58a	-0.57c	5.64e
50**	49.29	-13.55	21.81	54.26a	-2.97b	8.62d

Mean values with different letters in dried leaves columns are significantly different ($p < 0.05$) based on DMRT

**Drying using pilot scale dryer with a capacity of 15 kg per batch

Table 4: Brix and pH of dried *Stevia* leaves

Sample	Brix (%)	pH
Fresh leaves	1.57a	6.99c
50 °C	6.87b	5.72c
60 °C	6.50b	5.67c
70 °C	5.40b	5.73c
50 °C*	5.60b	5.48c

Mean values with different letters in each column are significantly different ($p < 0.05$) based on DMRT

*Samples taken from pilot scale dryer

Table 5. Nutrient composition of dried *Stevia* leaves

Components	Quantity
Protein ¹	15.65
Fat ¹	1.0
Carbohydrate ¹ (CHO)	65.18
Fibre ¹	30.92
Ash ¹	8.80
Calcium ² (Ca)	620.31
Iron ² (Fe)	24.62
Phosphorous ² (P)	268.13
Potassium ² (K)	2,804.68
Sodium ² (Na)	35.57
Vitamin B2 ²	0.02
Vitamin C ²	16.60

¹g/100 g dry leaves

²mg/100 g dry leaves

fresh leaves and the amount increased to 5.5 – 6.9% in the dried leaves (Table 4). The pH was almost the same in both fresh and dried leaves. Slight changes in pH might be due to delay in drying, where the leaves started to ferment although they were stored in the cold room. The pH was in the range of 5.5 – 5.7. Similar pH readings were obtained from the analysis of *Stevia* grown in Egypt with total soluble sugars recorded around 4.13% (Abou-Arab et al. 2010).

Nutrient content in *Stevia* leaves

The nutrient content of *Stevia* leaves was very much dependent on the variety, soil conditions and agronomic practices during planting. Proximal and mineral analysis on *Stevia* leaves grown in Tamil Nadu, India, showed that the protein, fat, carbohydrate and ash content were found to be 20.42, 4.34, 35.20 and 13.12 g/100 g dry weight basis respectively (Tadhani and Subhash 2006). The leaves were also found to contain 13 types of minerals including potassium (K), calcium (Ca), magnesium (Mg) and phosphorous (P) at 2.51, 1.55, 0.5 and 0.35 mg/100 g respectively.

Stevia grown in the experimental plot in MARDI was found to contain similar nutrients but in different quantities. Protein, fat, carbohydrate, fibre and ash were found to be 15.65, 1.0, 65.18, 30.92 and 8.8 g/100 g respectively. The *Stevia* leaves were also found to contain minerals especially K, Ca, P and vitamin C (about 16.6 mg/100 g of dry leaves) (Table 5).

Conclusion

Stevia var. MSR 012, grown in the MARDI experimental plot, was dried using mechanical dryers to maintain the leaf quality during storage. The best drying temperature was found to be at 50 °C to maintain the physical and chemical content of the leaves. The leaves took 6 h to dry using a laboratory dryer at 50 °C. With the pilot scale dryer, more than 7 h was required to reduce the moisture content of the *Stevia* leaves from 80% to 3 – 5%. Drying at

50 °C produced leaves with brighter and greener colour compared to drying at higher temperatures. Locally grown *Stevia* leaves contained various types of nutrients and minerals such as protein, carbohydrate, K, Ca, P and also vitamin C.

Acknowledgement

The authors wish to thank Dr Tan Swee Lian, the project leader on *Stevia* in Malaysia for the financial support and advices. Special thanks and gratitude are given to Dr Muhammad Che Husin, Mr Mohd Fadzly Mail and his staffs for their assistance and effort in providing drying materials for the experiments. Special thanks and appreciation are also due to Mr Shafie Alwi and Mr Azlan Othman for their technical assistance.

References

- Abou-Arab, A.E., Abou-Arab, A.A and Abu-Salem, M.F. (2010). Physico-chemical assessment of natural sweeteners steviosides produced from *Stevia rebaudiana* (Bertoni) plant. *African Journal of Food Science* 4(5): 269 – 281
- Adapa, P.K., Sokhansanj, S. and Schoenau, G.J. (2007). Performance study of a re-circulating cabinet dryer using a household dehumidifier. *Drying Technology and International Journal* 20(8): 1673 – 1689
- AOAC (1990). *Official methods of analysis*. 15th ed. Washington, DC: Association of Official Analytical Chemists
- (1993). *Methods of analysis for nutrition labeling*. (Sullivan, D.M. and Carpenter, D.E., eds.). (Methods no. 985.29). Washington, DC: AOAC International
- Chopda, C.A. and Barrett, D.M. (2007). Optimization of guava juice and powder production. Department of Food Science and Technology, University of California Davis
- Demir, V., Gunhan, T., Yagcioglu, A.K. and Degirmencioglu, A. (2004). Mathematical modelling and the determination of some quality parameters of air-dried bay leaves. *Biosystems Engineering* 88 (3): 325 – 335
- Hatter, K. (2010). How to dry *Stevia* leaves? Retrieved on 1 December 2010 from http://www.ehow.com/how_7253313_dry-stevia-leaves.html

- Khan, E.M. (2009). Effect of sowing date and cultivar on leaf yield and seed production of coriander (*Coriandrum sativum* L.). *Journal of Food, Agriculture and Environment* 7(2): 332 – 334
- Midmore, D.J. and Rank, A.H. (2002). A new rural industry– *Stevia* –to replace imported chemical sweeteners. A report for the Rural Industries Research and Development Corporation. RIRDC Web Publication No. W02/022. RIRDC Project No. UCQ -16A
- Samsudin, A., Ab. Aziz, I., Shafie, A. and Othman, O. (2004). Drying characteristics of kenaf for animal feed using laboratory and commercial dryers. *J. Trop. Agric. and Fd. Sc.* 32(1): 109 – 117
- Samsudin, A., Furuichi, S. and Shafie, A. (2005). Drying of oil palm fronds using laboratory and commercial dryers. *J. Trop. Agric. and Fd. Sc.* 33(1): 131 – 140
- Shaw, M., Meda, V., Tabil Jr., L. and Opoku, A. (2007). Drying and colour characteristics of coriander foliage using convective thin-layer and microwave drying. *Journal of Microwave Power and Electromagnetic Energy* 41(2): 56 – 65
- Tadhani, M. and Subhash, R. (2006). Preliminary studies on *Stevia rebaudiana* leaves: Proximal composition, mineral analysis and phytochemical screening. *J. Med. Sci.* 6(3): 321 – 326
- Tan, S.L., Muhammad Ghawas, M., Mohamad Najib, M.Y. and Zawayi, M. (2008). Preliminary evaluation and selection of *Stevia* under Malaysian conditions. *J. Trop. Agric. and Fd. Sc.* 36(2): 171 – 177
- Yadav, A.K., Singh, S., Dhyani, D. and Ahuja, P.S. (2011). Review on the improvement of *Stevia* [*Stevia rebaudiana* (Bertoni)]. *Canadian Journal of Plant Science* 91(1): 1 – 27

Abstrak

Pengeringan pada suhu 50 – 60 °C adalah kaedah yang berkesan untuk mengeringkan pokok *Stevia*. Pada suhu ini, kualiti daun kering yang dihasilkan sangat baik daripada aspek warna, kemanisan dan kandungan nutrisi berbanding dengan pengeringan pada suhu 70 °C. Proses pengeringan menggunakan mesin pengering di makmal mengambil masa 5 hingga 6 jam dan lebih 7 jam di peringkat perintis untuk menurunkan kandungan lembapan daun *Stevia* daripada 80% kepada 3 – 5%. Sejumlah 72 – 74% daun *Stevia* kering diperoleh selepas diasingkan daripada tangkainya. Daun yang telah dikeringkan kelihatan lebih cerah (L^*), kehijauan (a^*) dan sedikit kekuningan (b^*) masing-masing dengan nilai 54, – 3.0 dan 9.0 apabila pengeringan dilakukan pada 50 °C berbanding dengan sampel yang dikering pada suhu 60 – 70 °C. Daun *Stevia* kering mengandungi pemanis ‘stevioside’ dan pelbagai nutrisi serta mineral. Setiap 100 g daun *Stevia* kering mengandungi 16 g protein, 65 g karbohidrat, 2,805 mg kalium, 620 mg kalsium, 268 mg fosforus dan 16 mg vitamin C. Daun *Stevia* kering juga mengandungi gula pada ukuran 5 – 7 % brix dengan pH pada aras sekitar 6.