Drying and protein content in *Moringa oleifera* Lam. leaves

Carrión-Delgado, J.M.[1, 2]**; Valdés-Rodríguez, O. A.**[2*]

[1] Tecnológico Nacional de México Campus Xalapa. Xalapa, Veracruz, México. C. P. 91096.
[2] El Colegio de Veracruz, Xalapa, Veracruz, México. C. P. 91000.
* Corresponding author: oavaldesr@colver.edu.mx

ABSTRACT

Objective: To identify the appropriate climatic conditions for drying, as well as to validate the optimal procedure for solar dehydration and protein content in Moringa leaves from cultivars produced in the state of Veracruz.

Design/methodology/approach: The study period of this research was from October 2022 to September 2023. The plant material came from cultivars located in the Capital region and the Sotavento region, from the municipalities of Emiliano Zapata and Veracruz. The Dumas combustion method was applied. Moisture loss (ML) was determined using the gravimetric method, which involved measuring the change in weight of the sample before and after drying to calculate the moisture content. In the bromatological analysis (BA), the Acid Hydrolysis method was used, and it was quantified using the liquid chromatography (HPLC) technique to determine the nutritional composition of the foods.

Results: In the months of March, April and May, the relative humidity registered a low level, which is beneficial for the efficient operation of the dehydrator and accelerates the dehydration process. The results of the bromatological analysis reveal small differences in the contents of ash, protein, crude fiber and fat in the Moringa leaves of the municipalities studied.

Limitations on study/implications: The study period was less than one year.

Findings/conclusions: It was found that Moringa leaves from the municipality of Emiliano Zapata have higher protein, crude fiber and fat content than those from Veracruz. However, both are superior to other Moringa cultivars from the state of Veracruz.

Keywords: Bromatological content, indirect drying, proteins, relative humidity.

INTRODUCTION

Moringa oleifera Lam. (Moringaceae) is a tree native to India and Pakistan, capable of adapting to hot climates and scarce rainfall (Olson and Alvarado-Cárdenas, 2016); therefore, it is considered a resilient species under the new conditions of climate change (Carrión-Delgado *et al.*, 2023). In addition, the various parts of the plant such as leaves, roots, bark, flowers and pods are consumed for therapeutic purposes to treat different diseases (Asensi *et al.*, 2017). These parts have a high nutritional value, such as vitamins, minerals and essential amino acids, which gives it an important role in preventing and combating malnutrition (Asensi *et al.*, 2017). Studies carried out by Iglesias Díaz *et al.* (2018) and Ruiz-Hernández *et al.* (2021) demonstrate the benefits of Moringa in human nutrition and health. Meanwhile, Salmerón Sánchez (2013) explains that growing this

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species provides a series of advantages, such as positive impacts on food sovereignty and favoring an increase in the economic income of families; it also plays a fundamental role in the stability of ecosystems and is an essential part of cultural diversity. On the other hand, Meza-Carranco *et al*. (2016) mention that identifying the agroclimatic conditions of Moringa is essential to understand the factors that influence its cultivation and development, which can help increase its production and quality. Normally, conservation of the leaves is carried out through open-air solar dehydration. Dehydration involves removing moisture through the simultaneous transfer of heat via mass (Iglesias Díaz *et al*., 2018a). However, protein can be denatured during the dehydration process due to temperature, which can affect its conservation (Quintanilla-Medina *et al*., 2018). The artificial dehydration process affects its properties but facilitates its conservation, distribution and marketing (Sivipaucar *et al*., 2010). In Veracruz, there are commercial crops of Moringa in areas with high agroecological potential for this crop (Carrión Delgado *et al*., 2021), although producers lack an adequate dehydration method to guarantee the improvement of the leaf quality. Based on the above, the objective of this study was to identify the appropriate climatic conditions for drying, as well as to validate the optimal procedure for solar dehydration and protein content in Moringa leaves from cultivars in the state of Veracruz.

MATERIALS AND METHODS

The study was carried out from October 2022 to September 2023 on two cultivars in the state of Veracruz, in the municipalities of Emiliano Zapata (between parallels 19° 35' N and 19° 20' N, and meridians 96° 32' W and 96° 54' W) and Veracruz (between parallels 19° 06' N and 19° 16' N, and meridians 96° 07' W and 96° 21' W) because they belong to cooperating producers. A detailed characterization of the climatic conditions of these two municipalities was carried out, and open databases of the Global Energy Resources Project were consulted for this purpose (Nasa Langley Research Center, 2022), as well as historical climate records of average temperature, relative humidity, rainfall patterns, and other climatic factors that contributed to the determination of monthly relative humidity (MRH) and levels of monthly irradiance (E) in the municipalities in question. The data were analyzed through the NASA Power Web mapping application (NASA Prediction of Worldwide Energy Resources, 2021)

Sample selection

For sampling and collecting Moringa leaves, 10 plants were randomly selected, and the intermediate branches were cut until reaching a total of 1 kg. The compound leaves were separated from the stems, which were discarded, to obtain five 100 g samples (using an SF400 analytical scale), which were placed in transparent polyethylene bags with a hermetic seal. Each sample was labeled and placed inside a corrugated cardboard container in order to reduce cellular respiration during transfer to the dehydrator.

Solar dehydration and protein content

The dehydration process was carried out using a forced air solar dehydrator. The average external ambient temperature during the process was 23 °C (measured with a

Termio15 Datalogger thermometer). The internal temperature of the dehydrator was kept constant at 60 °C. The total dehydration time was 2 hours, following the recommendations by Iglesias Díaz *et al.* (2018b). At the end of this process, the samples were weighed again on an analytical scale (Electronic SF-400) to determine the moisture loss. After drying, the Dumas combustion method was used to determine the ash content (Muñoz-Huerta *et al.*, 2013; Miranda *et al.*, 2016), which consisted of charring 500 g of Moringa leaves to remove organic matter and obtain only inorganic ashes. The moisture loss (ML) was determined using the gravimetric method, which implied measuring the change in weight of the sample before and after drying. In the bromatological analysis (BA), the Acid Hydrolysis method was used, and the nutritional composition of the leaves was quantified using the liquid chromatography technique (HPLC). With this analysis, the percentages of macronutrients present in the sample were determined, as well as the content of crude fiber (CF), protein (Pro), fat (g), carbohydrates (CHO), and energy content (EC).

RESULTS AND DISCUSSION

Figure 1 presents the monthly relative humidity (RH) values by municipality. It shows that during the months of March, April and May, the RH registered a low level, which is beneficial for the efficient operation of the dehydrator and accelerates the dehydration process. However, in the other months, the high water vapor saturation makes the process difficult, resulting in longer dehydration time and increasing the risk of mold contamination. This situation can negatively affect the quality of the dehydrated product (Quintanilla-Medina *et al.*, 2018).

Throughout 2022, no differences were found in irradiance levels in the municipalities of Emiliano Zapata and Veracruz (Nasa Power, 2021). This is because they are located in the same geographical zone and have similar climatic conditions, as shown in Table 1. In both municipalities, the highest levels of irradiance are found in the months of March to August, which is beneficial for the generation of solar energy and contributes

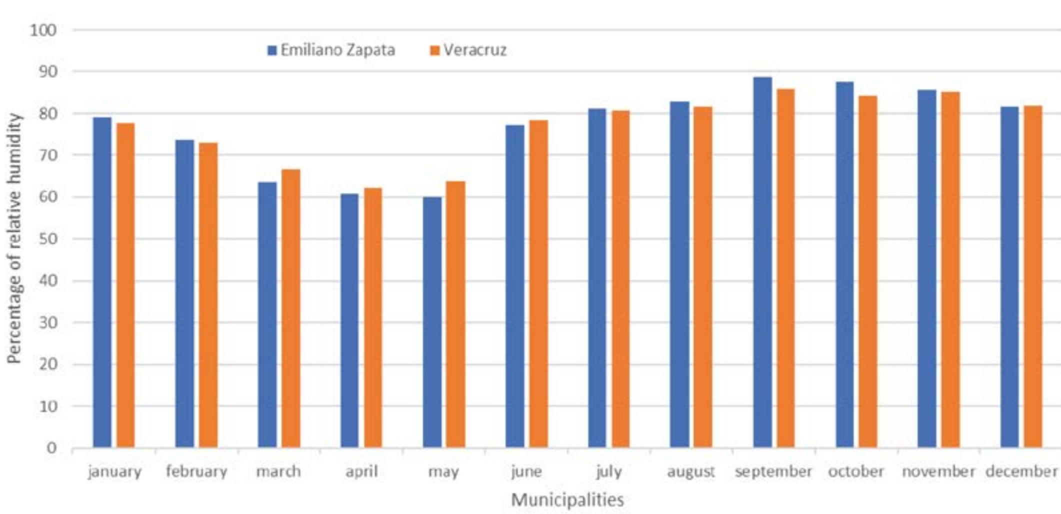

Figure 1. Average monthly relative humidity by municipality (2022).

significantly to the dehydration process of the raw material (Viveros Folleco and Mayorga Castellanos, 2017).

Table 2 presents the relevant data from the bromatological analysis of Moringa leaves, divided by municipality. It was observed that the ashes from the samples from Emiliano Zapata have a higher content, with 8.0%, compared to the samples from Veracruz (3.69%). It is important to highlight that the ashes provide us with information about the elements present in Moringa, such as copper, magnesium, potassium, phosphorus, calcium and zinc (Lezama *et al.*, 2017). In addition, when comparing the protein levels, it was seen that the samples from the crop in Emiliano Zapata have a percentage of 1.40% higher, compared to the samples from Veracruz. It is relevant to highlight that proteins are essential components for a balanced diet and play a crucial role in the body (Quintanilla-Medina *et al.*, 2018). Regarding crude fiber, the results indicate that the sample from Emiliano Zapata has 6.81% more than the sample from Veracruz. Crude fiber is the non-soluble combustible organic residue that represents the cellulose content, and its presence in food is important for good

Table 1. Average monthly irradiance by municipality (2022).

Month	Emiliano Zapata (W/m^2)	Veracruz (W/m^2)
January	3.565	3.565
February	4.310	4.310
March	5.426	5.426
April	5.967	5.967
May	6.334	6.334
June	5.595	5.595
July	5.925	5.925
August	6.095	6.095
Septiember	4.536	4.536
Octuber	4.300	4.300
November	3.924	3.924
December	3.539	3.539
Yearly E (W/m^2)	4.965	4.965

E=irradiance; W/m^2=Watts by square meter.

Table 2. Bromatological content of dehydrated moringa leaves.

Parameter	Emiliano Zapata		Veracruz	
	Result	Unids	Result	Unids
Humidity	9.0	%	8.0	%
Ashes	8.0	%	3.7	%
Crude fiber	23.0	%	16.2	%
Proteins	25.0	%	23.6	%
Oil (ethereal extract)	6.0	%	2.3	%
Carbohydrates (Nitrogen-free extract)	29.0	%	18.0	%
Energy content	270.0	Kcal/100 g	263.0	Kcal/100 g

digestive health (Quintanilla-Medina *et al*., 2018). Finally, in relation to fat levels, the data show that the samples from Emiliano Zapata contain 3.7% more lipids than those from Veracruz. The results of the bromatological analysis reveal small differences in the contents of ash, protein, crude fiber and fat in the Moringa leaves from the municipalities studied. However, these results, in terms of protein and ash, are superior to other plantations in the Sotavento region, which range between 17.7% and 19.9% protein and 10.6 and 12.3% ash (Ruiz-Hernández *et al*., 2021). This is because the type of soil and its fertility affect the nutritional content of the leaves, so more studies are required with other cultivars from the state to have a better characterization (Cerdas-Ramírez, 2017).

CONCLUSIONS

The results show that the months of March, April and May are the most favourable for efficient operation of the dehydrator, due to the low relative humidity levels. This accelerates the dehydration process. However, in the remaining months, high water vapor saturation makes the process more difficult, resulting in longer dehydration time and a higher risk of mold contamination. These factors can negatively affect the quality of the dehydrated product. Therefore, it is important to take into account the variation in relative humidity throughout the year to ensure an efficient dehydration process and high quality of the final product.

The municipalities of Emiliano Zapata and Veracruz presented similar irradiance levels throughout 2022. These findings are relevant for the development of solar energy projects within these municipalities, as they indicate there is a consistent potential over the year to harness this renewable energy source.

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