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ANALYSIS OF THE THERMAL BEHAVIOR OF A TUNNEL-TYPE DRYER WITH HYBRIDIZATION OF SOLAR TECHNOLOGIES

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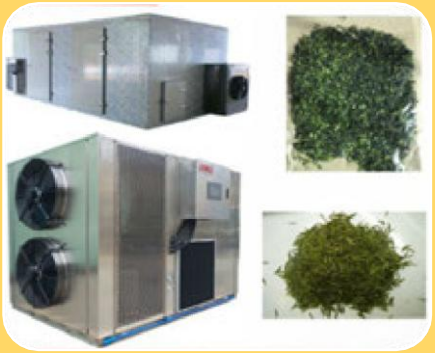
Importance of drying



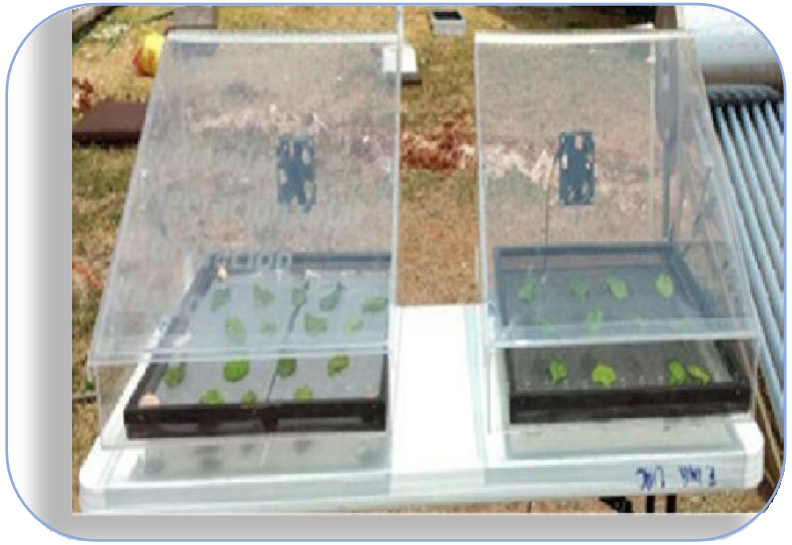
In México, according to Secretaría de Salud at least 90% of the population uses medicinal plants for to treat diseas and as nutritional suplement

Drying is the most common method of preserving medicinal plants, but due to the high investment on energy costs, it represents an elevated expense

Solar drying is a technology that is harmless with the environment and has a very low energy cost.

Solar drying technologies

The objective of this study is to analyse the degradation of medicinal plants leaves in diferents ways of receiving solar irradiation, 3 solar drying technologies were evaluate



DIRECT SOLAR DRYER CABINET TYPE (NATURAL AND FORCED CONVECTION)

INDIRECT SOLAR DRYER TUNNEL TYPE

GREENHOUSE SOLAR DRYER

In three cases, photovoltaics cells were used.

In tunnel and greenhouse dryer, solar heaters, heat exchangers and air collectors, were used.

Raw material

Mentha Spicata

Cymbopogon

Annona muricata L.

We select these medicinal plants because they have different characteristics in their leaves, and are very common in Campeche, México

Campeche location

Materials, methods and equipment

Water activity

Thermometers, Anemometers

Moisture balance

Measuring equipment was used to control the drying process

Weather Station

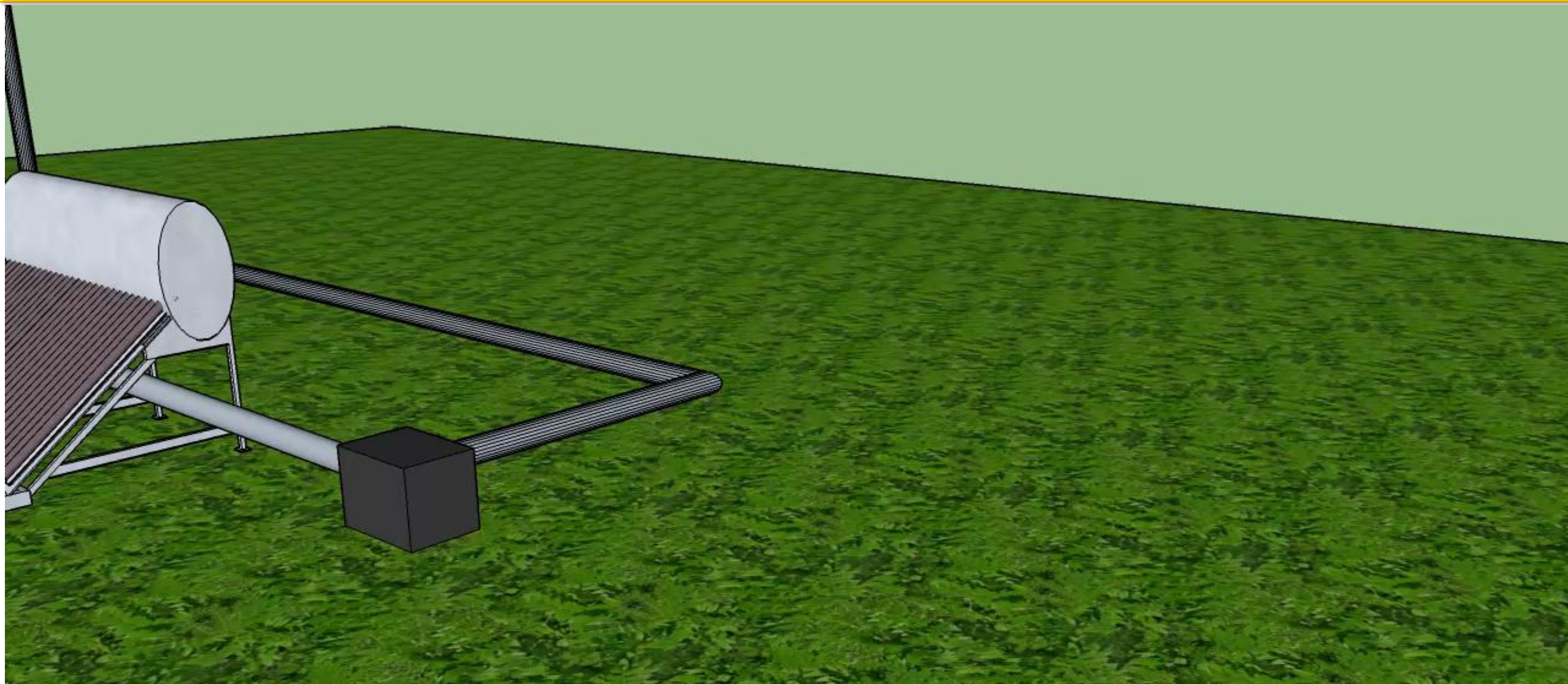
Flow meters

Hygrometer

Colorimeter

Temperature controlled oven

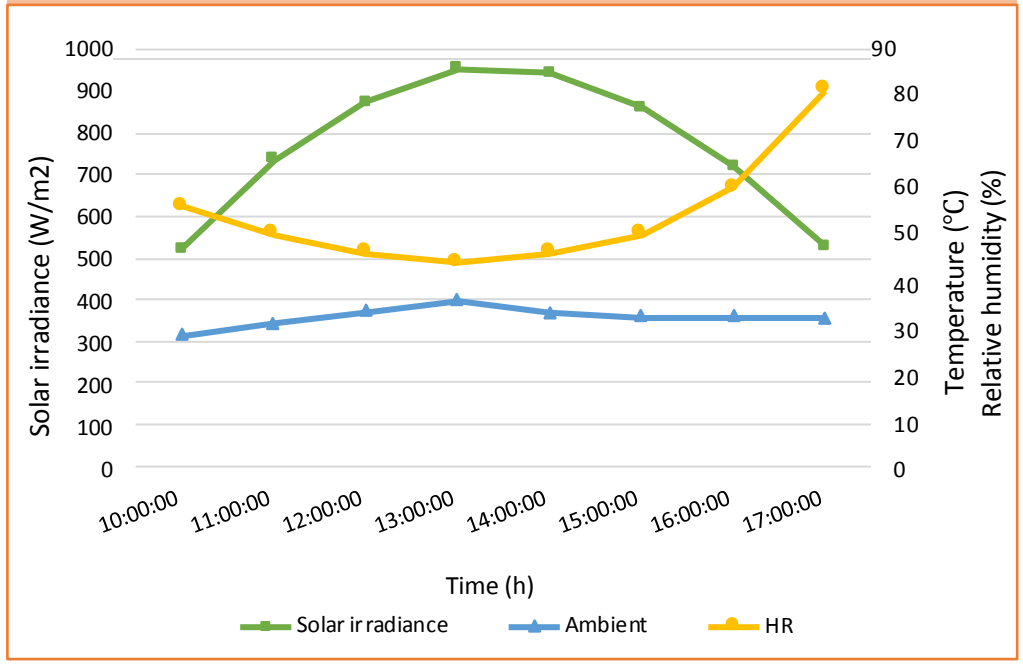
The best technology were the tunnel dryer working with solar heaters, heat exchangers and air collectors



Weather conditions

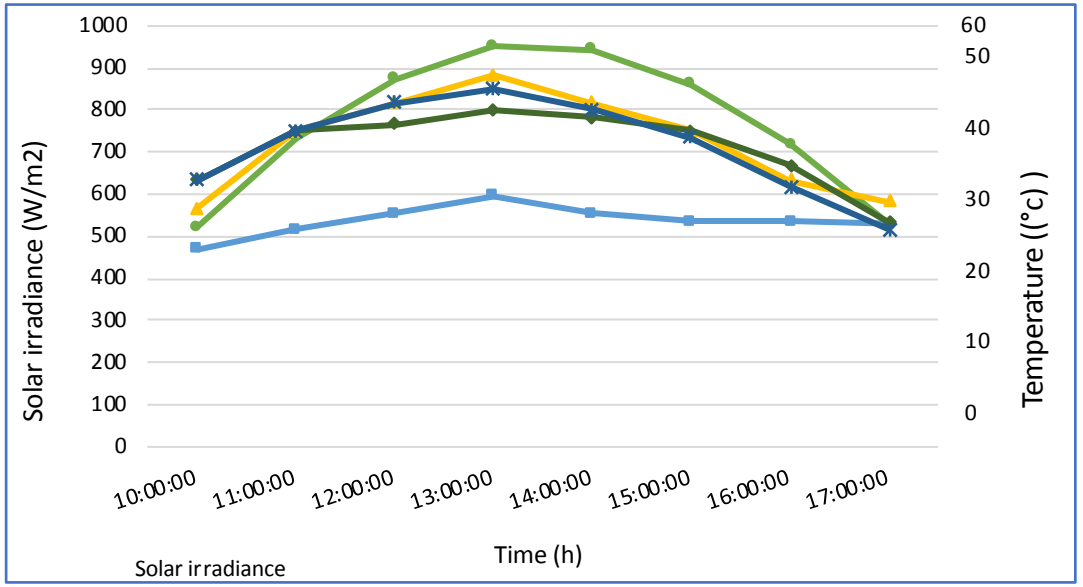
Climatic parameters

The maximum measured in solar irradiation was 900 W/m²; Ambient temperature 40°C, and HR minimum 50%



Comparison of climatic parameters and temperatures reached in the tunnel dryer working with evacuated tubes and solar air heater

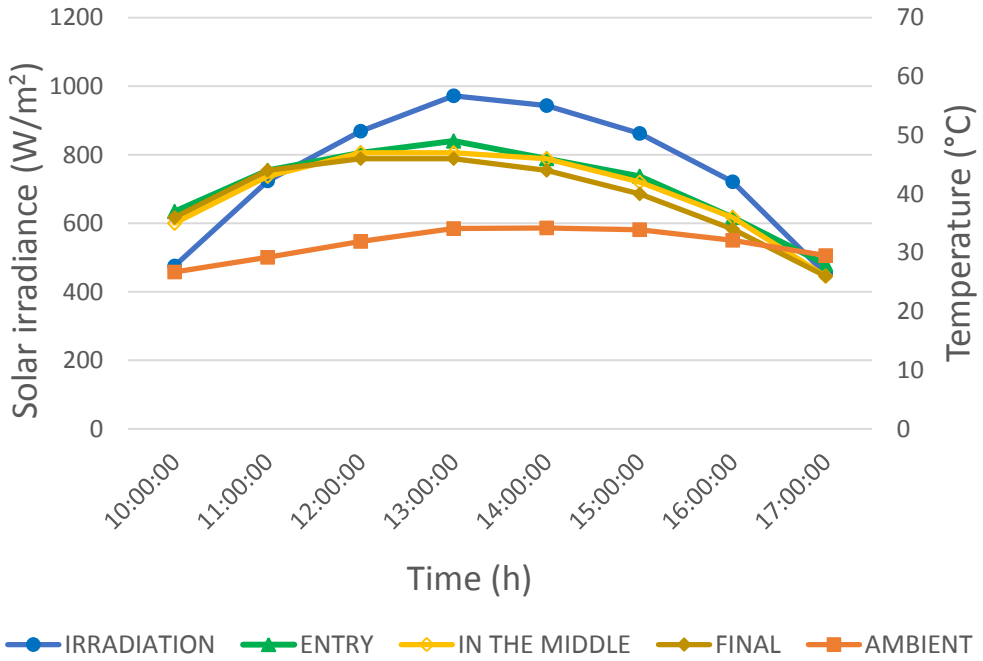
The maximum temperature measured in the drying chamber was 55°C. At the entry, in the middle and at the final of the drying chamber the temperatures were very similar



Weather conditions

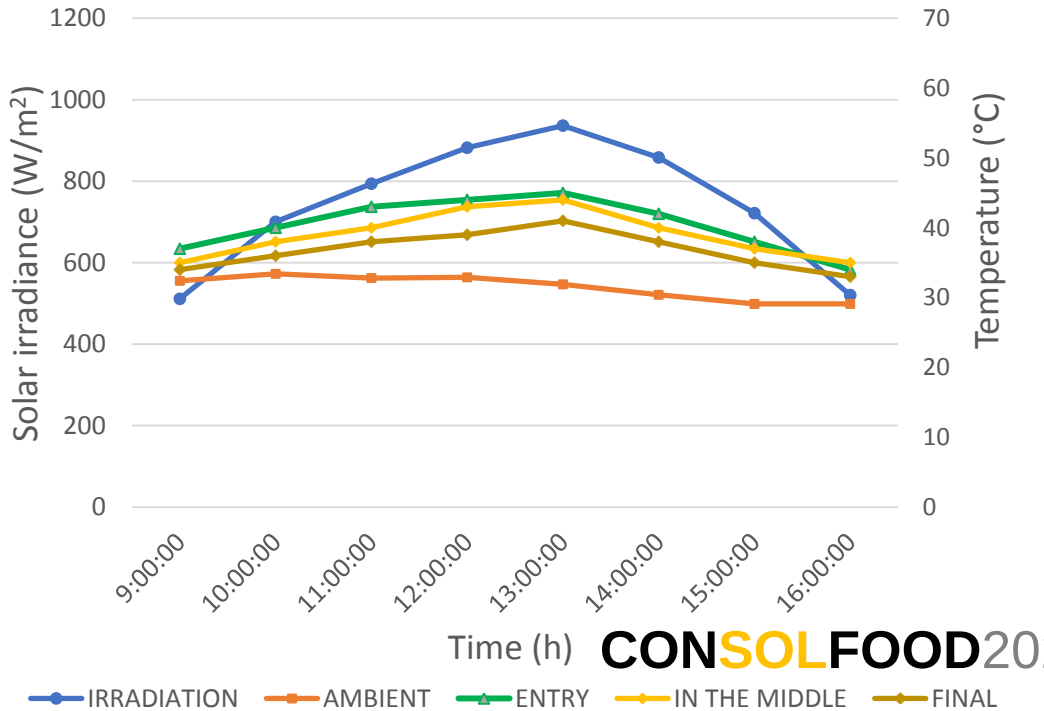
Comparison of climatic parameters and temperatures reached in the indirect solar tunnel dryer working with solar air heater

The maximum temperature measured in the drying chamber was 47°C



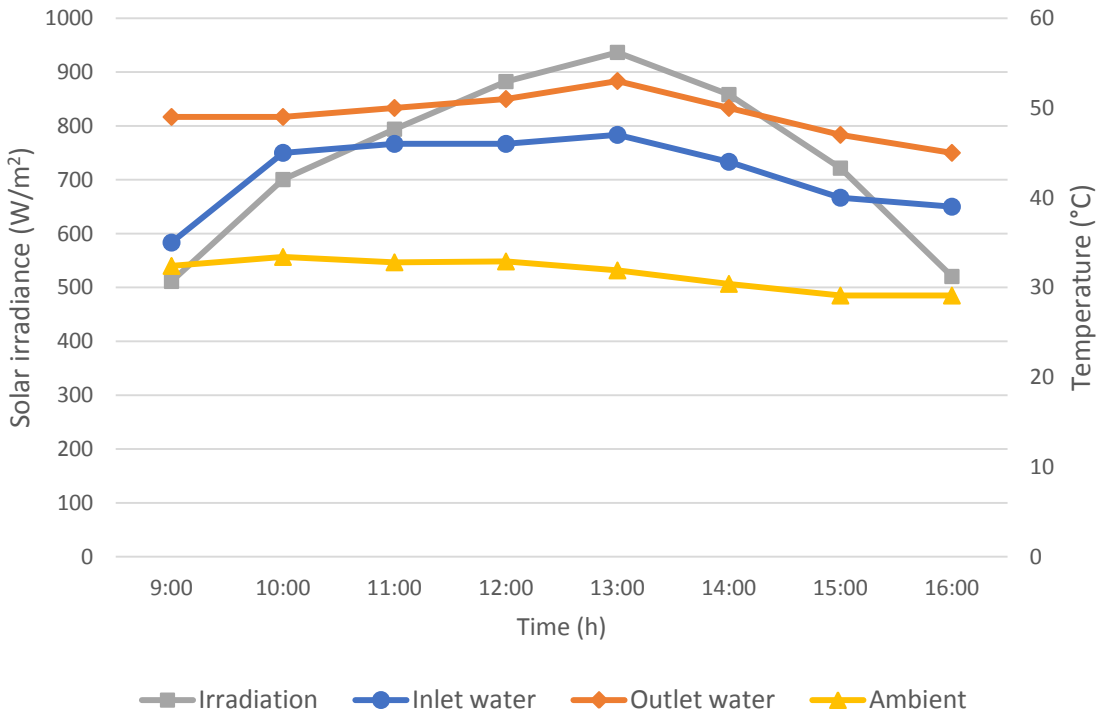
Comparison of climatic parameters and temperatures reached in the indirect solar tunnel dryer working with evacuated tubes

The maximum temperature measured in the drying chamber was 44°C



Weather conditions

Inlet and outlet temperature of the supply water in the evacuated tube solar heater



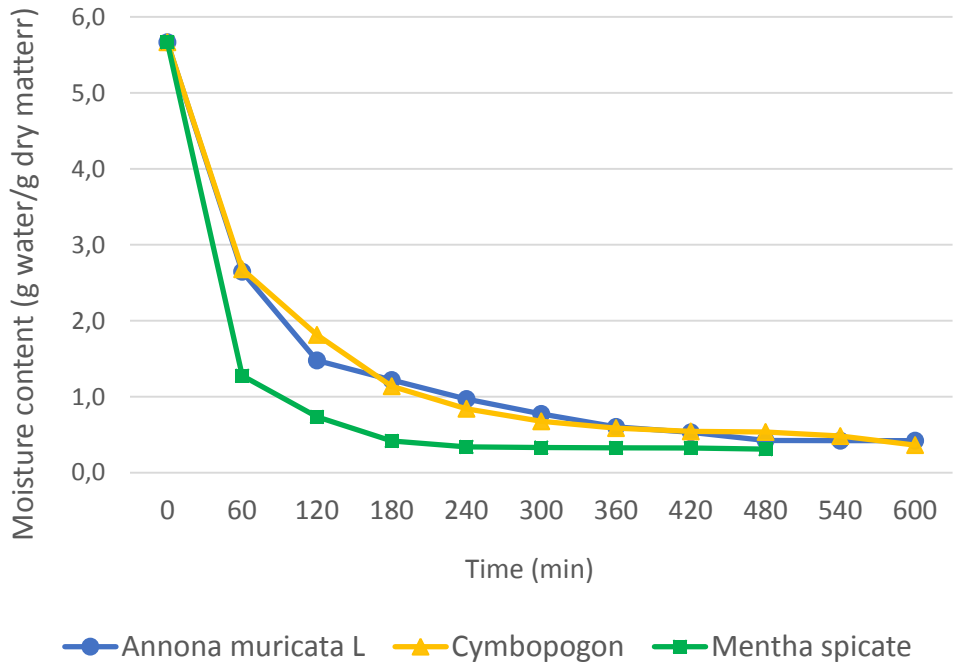
The maximum temperature measured of the inlet water was 47°C to the 13:00 o'clock.

The maximum temperature measured of the outlet water was 53°C to the 13:00 o'clock.

It is important to note that both at the inlet and at the outlet, the water temperature remains constant

Drying kinetics:

Variation of moisture content with respect to the drying time in the three medicinal plants studied.



The fastest kinetics was Mentha spicata, both *Annona* and *Cymbopogon* showed very similar curves in all the cases

Colorimetric study:

Medicinal plant / Dryer operation mode	*Annona muricata L.*		*Cymbopogon*		*Mentha spicate*	
	ΔE	Time	ΔE	Time	ΔE	Time
Tunnel type	10	450	11	420	14	300

Medicinal plants / *Drying method*	*Annona muricate L*	*Cymbopogon*	*Mentha spicate*
Tunnel type			

Humidity and Aw

In all samples we perform tests of Humidity and Water activity

	Solar dryer tunnel			
Cymbopogon	73.632	8.27	0.99	0.46
Mentha spicate	79.581	11.11	0.96	0.4
Annona muricata	68.177	10.03	0.98	0.42

The final water activity and humidity have values that guarantee that will be no bacterian growth or fungi in dry leaves.

Conclusions

The fastest kinetics was Mentha spicata, both annona and Cimpobogón showed very similar curves in all the cases studied

In all the cases studied, a final moisture was obtained in the products according to the commercial standards, therefore, it is guaranteed that the proliferation of microorganisms that degrade the dehydrated product is avoided.

The temperatures with which a higher quality was achieved in terms of coloration of the dehydrated leaves were in the temperature range between 45°C and 55°C.

For Mexican producers, these results are very important since they demonstrate that with the available solar energy and the drying technologies evaluated, it is feasible to use solar energy to dehydrate agricultural products.

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THANK YOU VERY MUCH

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