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Determination of drying costs to obtain parchment coffee in Oaxaca's Cañada region

Determinación de los costos de secado para la obtención de café pergamino en la región de la Cañada de Oaxaca

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Abstract

One of the little studied technological components in coffee production is the drying process, it is the most difficult, and expensive operation, representing between 45 and 60% of the processing costs. In addition, is the stage that concentrates 49% of the time used in the benefited process. The central objective of drying the grain is to avoid its deterioration and preserve its quality during storage. This stage is critical and requires control, since, it is decisive for the organoleptic quality of the drink due to its direct impact on the quality sensory. The unit costs of drying one kg of washed coffee and transforming it into parchment coffee, for the 2023 harvest season, were on average; $35.91, 31.87 and 44.88, for the solar, traditional and african bed drying systems, respectively. The unit costs depend on the initial investment for the construction of the drying system: 69.6% in solar drying and 83.2% in the african bed system.

Dry kinetics, DDrying methods, Nutraceutical quality

Resumen

Uno de los componentes tecnológicos poco estudiados en la producción de café, es el proceso de secado. Es la operación más difícil y costosa, llegando a representar entre el 45 y 60% de los costos de procesamiento. Además, es la etapa que concentra el 49% del tiempo utilizado en el proceso de beneficiado. El objetivo central del secado del grano es evitar su deterioro y conservar su calidad durante el almacenamiento, esta etapa es crítica y requiere control, ya que, es determinante para la calidad organoléptica de la bebida por su repercusión directa en la calidad sensorial. Los costos unitarios de secar un kg de café lavado y transformarlo en café pergamino, para la temporada de cosecha 2023, fue en promedio; $35.91, 31.87 y 44.88, para los sistemas de secado solar, tradicional y camas africanas, respectivamente. Los costos unitarios dependen de la inversión inicial para la construcción del sistema de secado: 69.6% en el secado solar y 83.2% en el sistema de camas africanas.

Cinética de secado, Métodos de secado, Calidad nutraceutica

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Introduction

In Mexico, coffee growing is one of the most important crops in the agricultural sector, especially in rural communities. Production areas are concentrated in 12 states, mainly in small production units in mountainous areas, with the states of Chiapas, Veracruz, Puebla and Oaxaca accounting for 81.1% of national production (SIAP, 2022).

The process of transforming cherry coffee into parchment coffee is known as processing and begins with the cutting and harvesting of coffee cherries with an ideally homogeneous maturity until dry coffee is obtained, known as parchment coffee, since the bean is covered by an opaque yellow layer called parchment (Ortega, 2010).

One of the little studied technological components in coffee production is the drying process, which is the most difficult and costly operation, representing between 45 and 60% of processing costs. It is also the stage that accounts for 49% of the time spent in the processing process (Valderrábano, 2011). On the other hand, coffee beans are very difficult to dry to the recommended range of 10-12% for the following reasons:

- The initial moisture to start drying, can vary from 48 to 56%, acquired by the bean in the washing stage; and it is sought to reduce it to the range of 10 to 12% (IICA, 2010).

- If drying is carried out quickly, the parchment hardens. This affects the physical-chemical nature of the parchment (endocarp) and the grain or endosperm.

- When high drying temperatures are used, aromatic components are volatized. Conversely, if low temperatures are used, the physical appearance of the bean is poor and even the taste of the beverage is affected.

The main objective of drying the bean is to avoid its deterioration and preserve its quality during storage, this stage is critical and requires control, as it is decisive for the organoleptic quality of the beverage, due to its direct impact on the sensory quality and directly influences the final price given to the product (Ventura-Cruz et al., 2019).

Coffee drying depends, among other factors, on the prevailing environmental conditions during the process (Prada et al., 2019). In tropical climates, it deteriorates by up to 50%, due to constant rainfall, during the harvest season. This decreases the market value and generates economic losses for the producer (Guevara-Sánchez et al., 2019).

One of the alternatives to improve the coffee drying process is to use solar energy, through the use of solar dryers (Hii et al., 2019), as it allows increasing and stabilising its production and increasing the safety of the final product by protecting it against dust, rain, insects, birds, rodents and domestic animals and thus being able to increase the selling price of the product, due to a higher quality (Tomar et al., 2017; García et al., 2022). Currently, there is a wide variety of designs and sizes of solar dryers that can be used for drying various foods of agricultural origin (Ahmadi et al., 2021). They are low capital and low maintenance cost installations, easy to construct and any material available in the construction area can be used, with designs tending towards simplicity, as there is no significant difference in the results obtained with the more primitive designs compared to the more sophisticated ones (Sharma et al., 2018).

The objective of this study is to compare the costs of setting up and operating a solar dryer for coffee beans, compared to a traditional drying system in African beds and on mats in the Cañada region of the state of Oaxaca. The aim is to reduce contamination by animal fauna and the difficulties of environmental conditions, and with this, increase the sale price of the final product.

Materials and method

The study was carried out in the coffee-growing area of the Cañada region of the state of Oaxaca, in the municipality of Santa Cruz Acatepec belonging to the District of Huautla de Jiménez. The dryer is located in the following geographic location: 18° 9' 44" N and 96° 52' 36" W, at an altitude of 1617 m.

The design of the solar dryer is zenithal (Fig. 1), measuring 7.50 m long and 4 m wide. It has 3 drying levels with 12 screens per level and a total capacity of 36 screens, drying up to 240 kg of wet parchment coffee per cycle, in an average of 8-10 days.

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Figure 1 Design of the zenith type solar dryer for coffee drying

For the economic analysis, a producer with experience in speciality coffees (> 84 SCA protocol points) was chosen, with whom the solar dryer was built, and all the activities and quantities of materials purchased for the implementation of the dryer were recorded, in order to estimate the total investment and calculate the profitability of the construction.

For the evaluation of economic indicators, it was determined:

1. The cost of drying to obtain a kilogram of parchment coffee (Quintanar and Roa, 2017; Singh and Gaur, 2020; Garcia et al., 2022), using the following equations:

$$C_{us} = \frac{C_{an}}{P_{sa}}$$

Where:

C_{an} Total annual cost of the solar dryer.

P_{sa} Total amount of product dried in the solar dryer annually.

Solar dryer annually

To obtain the above, it was necessary to determine the following values:

A. The annual cost of the solar dryer (C_{as}) is given as.

$$C_{as} = C_{ca} + C_{mt} - V_r + C_{oa}$$

Where:

C_{ca} Annual capital cost, including initial infrastructure initial cost of infrastructure,

C_{mt} Annual maintenance cost of the solar dryer.

C_{oa} Annual operating cost of the dryer.

B. The total amount of products dried annually in the solar dryer (P_{sa}) is given by:

$$P_{sa} = \frac{M_{ps} D_u}{D_n}$$

Where:

M_{ps} Batch-dried product mass in a solar dryer solar dryer,

D_u Number of days during which the dryer is used dryer is used in the year,

D_n Number of days required to dry the material per batch.

Results and discussion

Cost of setting up a solar dryer

At the end of the construction of the solar dryer, all the costs of materials and labour that were used were quantified in order to have an estimated total cost for the implementation of the solar dryer. The initial cost estimate was $11,770.00 pesos, where 65.3% corresponds to the cost of materials, 34.7% to the cost of labour for construction (Table 1). Over the course of a drying cycle, two workdays were employed to handle the wet parchment. However, due to the dew or rain protection infrastructure during the annual drying season, this is considerably reduced as the grain does not have to be stored on a daily basis.

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Material	Quantity	Unit price ($)	Total cost ($)	%
9 x 9 x 259 cm long poles (16 full and 10 halved)	26 pzs	70	1,820	**69.6**
6 cm wide x 2.5 cm thick x 250 cm long sized timber	72 pzs	40	2,880	
7.5 cm wide x 2.5 cm thick x 250 cm long sized timber	52 pzs	45	2,340	
3.7 m wide, 50% shade netting	8 m	85	680	
7.5 m wide greenhouse plastic (720 gauge)	12 m	110	1,320	
5", 3", 2" and ½" nails	3 kg	80	240	
3" hinge	3 pzs	15	45	
Sub-total materials			**9,325**	
Labour (dryer construction)	30 jornales	120	3,600	**30.4**
Labour (sieve construction)	4 jornales	120	480	
Subtotal daily wages			**4,080**	
Total cost of infrastructure			**13,405**	**100**

Table 1 Set-up costs of a solar overhead dryer with three drying levels.Cost of traditional drying

The materials used for this type of drying are two mats and two sacks for daily storage, so the total investment of materials would be $236.00 pesos, which is the only investment, since it does not require labour for the construction of infrastructure. The amount of labour for a drying cycle is one and a half days due to the need to take out and put in the wet parchment coffee daily, as well as having to move it during the hottest hours and store the beans in case of fog or rain.

Cost of setting up on African beds

For drying in African beds, Table 2 lists the materials used to make them, in order to quantify the total cost for their construction, with an approximate total of $2,060.00 pesos, where 82.5% corresponds to the cost of materials and 17.5% to the cost of labour for making the beds. Three working days were estimated to carry out one drying cycle, mainly due to the need to remove and place the wet parchment coffee in the African beds on a daily basis. In addition, having to move it during the hottest hours and storing the beans in case of rain.

Comparing the total costs of materials used and adding the operating costs over a harvest cycle (season), it was found that the unit cost ($/kg) for each type of drying presented considerable differences for transforming washed coffee and transforming it into dry parchment coffee (10 to 12% humidity of the bean).

Material	Quantity	Price/ unit ($)	Total cost ($)	%
Galvanised wire screen mesh (5 squares per inch)	1 roll	1800	1800	**83.2**
2.5 m long poles (8 whole and 4 split in half)	12	70	840	
7.5 cm wide x 2.5 cm thick x 250 cm long dimensioned timber	4	45	180	
Sacks	4	8	32	
1" nail	1.5 kg	90	135	
Sub-total materials			**2,987**	
Day labour for the construction of African beds	5	120	600	**16.8**
Subtotal daily wages			**600**	
Total cost of infrastructure			**3,587**	**100**

Table 2 Establishment costs for implementing drying on African beds

Comparing the total costs of materials used and adding the operating costs over a harvest cycle (season), it was found that the unit cost ($/kg) for each type of drying presented differences for transforming washed coffee and transforming it into dried parchment coffee (10 to 12% humidity of the bean). Thus, the unit costs of drying one kg of washed coffee and transforming it into parchment coffee by using a zenith solar dryer, drying on mats and drying on African beds were $35.91, $31.87 and $44.88, respectively. These are the average costs for the 2023 harvest season (Table 3). Although the cost of solar drying was not the lowest of the three systems compared, the volume of drying was the highest, which translates into a higher harvest volume. The result obtained reflects that the cost of drying in a solar dryer is quite similar to the cost of drying in a traditional way, which represents a difference of $4.04 pesos per kilogram of parchment coffee dried. This indicates that the investment to set up a solar dryer can be justified due to the possibility of improving the selling price of the product.

Table 3. Estimated economic variables for three types of drying in the cañada region, Oaxaca.

Economic variables	Solar dryer	Backpack	African bed
Ct: cost of infrastructure	$13,405.00	$236.00	$3,587.00
Annual seasonal labour cost*.	$960.00	$720.00	$1,440.00
Can: total annual drying cost	$14,365.00	$956.00	$5,027.00
Psa: Drying capacity per season (kg)	400	30	112
Cus: Cost per kilogram dried	**$35.91**	**$31.87**	**$44.88**
* One season considers on average four drying cycles.			

The results of comparing the drying costs are relatively high, with those reported by Garcia et al. (2022) for a solar drying process carried out in the same region and state.

The initial investment costs (inputs and materials) for the implementation of any drying technology are 69.6% for solar drying and 83.2% for the African bed system and 100% for mats. The drying capacity of parchment coffee for each of the above-mentioned systems is 400 kg, 112 kg and 30 kg, respectively, so this factor limits the drying time, the time of use of the dryer and the number of labourers to follow up the drying process (Poonia et al., 2019; García et al, 2022).

Conclusions

The unit cost for drying one kilogram of parchment coffee in a solar coffee dryer did not register a considerable difference compared to the other drying systems evaluated for the 2023 season, the implementation of a solar dryer can be justified due to the reduction of labour required for the handling of the beans and the higher drying capacity per unit area, in addition to the increase in the quality and safety of the final product.

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