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OBTAINING FLOUR FROM COFFEE WASTE FOR HUMAN CONSUMPTION
Obtención de harina a partir de desechos de café para consumo humano

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ABSTRACT

The drying of the coffee fruit is carried out as one of the previous activities to obtain the coffee bean, which is later used in different drinks. In this study, two alternative drying processes have been applied, and it has been evaluated if the amount of by-product obtained is significantly affected in order to elaborate a flour. The methodology consisted in obtaining the material that surrounds the coffee seed and drying through two different drying processes, which were: 1) Obtaining the pulp, with a manual pulper and then drying it in the sun and 2) Coffee dried directly by the sun and then pass it through a thresher.
Each experiment consisted of pulping 14 print runs of 115 pounds each; (leaving out 140 pounds of coffee that were delivered, but not taken into account in the statistical analysis, due to the difficulty of going down to the farms and taking measurements (statistically missing values); the data was recorded and tabulated to perform a t test comparison between independent samples. The research found that there is a statistical difference between the two drying processes since 2.66 pounds more are obtained than the process in which the coffee is first dried and then the pulp is obtained by threshing.

Palabras clave:
Pulpa, despulpado manual, trillado, harina, secado.

RESUMEN

El secado del fruto del cafeto se realiza como una de las actividades previas para obtener el grano de café que luego se utiliza en diferentes preparaciones. En este trabajo se han utilizado dos procesos alternativos de secado, y evaluado si la cantidad de subproducto obtenida se ve significativamente afectada para luego elaborar una harina. La metodología utilizada consistió en obtener el material que envuelve a la semilla del café y hacer el secado utilizando dos procesos de secado los cuales fueron: 1) Obtención de la pulpa, con una despulpadora manual para luego secarla al sol y 2) Café secado al sol para luego pasarla por una trilladora. Cada experimento consistió en el despulpado de 14 tirajes de 115 libras cada uno; (dejando por fuera 140 libras de café que fueron entregados, pero no tomados en cuenta en el análisis estadístico, por dificultad de bajar a las fincas y tomar mediciones (valores perdidos

	estadísticamente) los datos fueron registrados y tabulados para realizar una prueba *t* de comparación entre muestras independientes. La investigación encontró que existe diferencia estadística entre los dos procesos de secado ya que se obtienen 2.66 libras más que el proceso en que primero se seca el café y luego se obtiene la pulpa por trillado.

Introduction

It includes the presentation of the paper and the analysis of the literature on the subject, with special emphasis on previous research that justifies the study and that will then be contrasted in the discussion of the results.

All text is in 12-point Cambria font, single-spaced and with no spacing between paragraphs.

The present investigation attempts to compare the impact that two different drying methods have on the amount of pulp obtained after its separation from the coffee bean.

The yield of this process is important when considering the pulp, not as a disposable by-product, but as an input to extend the coffee production chain. In this case, by becoming raw material for the production of a flour suitable for human consumption.

Academic research and initiatives aimed at taking advantage of the by-product in question have been varied in the recent past; since, as has been demonstrated, achieving its objective implies reducing harmful impacts on ecosystems and generating income for economic actors who potentially perceive this activity as a source of profits.

The coffee bush is a shrub whose seed is ground and roasted to obtain a powder that serves as the base for the popular beverage known as coffee. Both the cultivation, harvesting and processing involved in the production chain have become a central activity for many companies and families, to the point that the economy of several countries is influenced by the commercial transactions that revolve around coffee. In view of the above, it is necessary to identify opportunities for improvement in all processing activities (Pérez et al., 2022), and to try to extend the production chain in order to minimize losses and waste.

There are several characteristics to take into account in the cultivation of coffee

Depending on the altitude at which it is grown, it can be classified as follows

- Lowland coffee between 400 and 800 meters above sea level (m.a.s.l.); Huizúcar coffee in the Department of La Libertad, like the one used for this research, is cultivated at 640 meters above sea level (m.a.s.l.).
- Average coffee from 800 to 1200 m.a.s.l.; coffee from the municipality of Jayaque in the Department of La Libertad, like the one used for this research, is cultivated at 998 m.a.s.l.
- High altitude coffee is grown from 1200 to 1600 meters above sea level

There are coffee plantations exposed directly to the sun that develop fruits with low weight and, therefore, low relative yields in comparison to those obtained in plantations under the shade of other trees that protect the coffee plants from the elements manifested in direct solar radiation, strong winds, copious rainfall, and high temperatures. On the other hand, producing under shade improves the landscape and biodiversity characteristic of complementary crops, among others:

- Agroforestry systems, which due to the diversity of woody species capture high levels of carbon in the plant biomass, helping to reduce negative environmental impacts caused by pollution and inadequate exploitation of natural resources; thus, coffee cultivation contributes to the sustainability of ecosystems (Valdés et al., 2023).
- Transient shading such as those formed by leguminous species, which are associated with nitrogen-fixing bacteria (Pérez et al., 2021), are good alternatives to conserve moisture and prevent soil degradation.

- Fruit plantations that are usually associated with coffee trees. Production systems are dominated by avocado (Persea americana), citrus (Citrus spp.), coconut (Cocos nucifera), chontaduro (Bactris gasipaes), guaba (Isonga edulis), papaya (Carica papaya) and pineapple (Ananas comosus). (Vargas et al., 2018)

Coffee fruit is classified as non-climacteric, as it does not ripen after being harvested (Martínez et al., 2017)

Once harvested, it is dried, roasted and ground to produce coffee powder.

As regards drying, two alternative processes are generally applied: one using mechanical dryers and the other using solar heat. The artisanal method consists of spreading the grain to be exposed to the sun using soil, cement patios, or plastic film (Medina et al., 2016)

After drying, as mentioned above, the grain is roasted and milled, a process that, once completed, yields an average of 60% of the grain. The 40% surplus is constituted by pulp: organic waste that being understood as a by-product is generally not taken advantage of, and whose management entails environmental impacts (Serna et al., 2018).

The environmental impact of coffee pulping is negative if it is not carried out responsibly. Their careless disposal could affect the edaphic microflora, where acidophilic fungi are the main metabolizers of organic matter (Cervantes et al., 2023).

However, a counterproposal to the simple action of discarding the pulp is to take advantage of its properties to expand the value chain by industrializing it as a raw material for various agroindustrial products. The pulp contains about 86% water, 43.58% of the dry fruit weight, 1.3% caffeine and is rich in carbohydrates, proteins, pectins, bioactive compounds such as polyphenols (Torres et al., 2019).

Various background information on how to use pulp and reduce waste can be found. In 2013, research was conducted on processes for obtaining honey and flour from coffee pulp (Ramírez & Jaramillo, 2013). The researchers set out to take advantage of coffee co-products in the development of raw materials that can be incorporated into the development of other products containing polyphenols, vitamins, proteins, and minerals suitable for human or animal consumption and that can be incorporated into medicines, cosmetics, and ethanol, among others. This was achieved by concentrating and conserving the mucilage to produce honey, and from the pulp they manufactured coffee pulp flour.

This last effort coincides with this research, as it aims to reduce environmental pollution (Ramírez Vélez, 2013) by reducing industrial waste, expanding the boundaries of the production process, and making the most of the coffee plant product whose pulp has bioactive compounds with functional characteristics, which allows its use as a raw material. (Serna et al., 2018)

In this sense, it is intended that the by-products of the coffee process are taken advantage of and can contribute to various social and economic sectors, to the national economy, to the generation of employment, and to the development of new products that contribute to consolidate food security.

Among the products that can be developed is a pulp flour, which is the proposal of this work, and which finds as preceding activities the comparison of two drying-pulping methods.

Drying is a process by which the coffee bean is dehydrated to prevent deterioration and thus preserve its quality during storage (Zactiti et al., 2004; Ventura-Cruz et al., 2019).

During 2019, research was conducted on the Effectiveness of a Coffee Drying Process using solar dryers with continuous air flow system and driven by photovoltaic energy (Prada et al., 2019); this in order to reduce drying time to obtain an average of 12% humidity. What was interesting about this research was that grain moisture was gradually reduced over five days and the usefulness of solar dryers was demonstrated (Prada et al., 2019).

With this background, the methodology used here is developed, followed by an analysis of the drying-pulping processes and their outstanding results.

Method

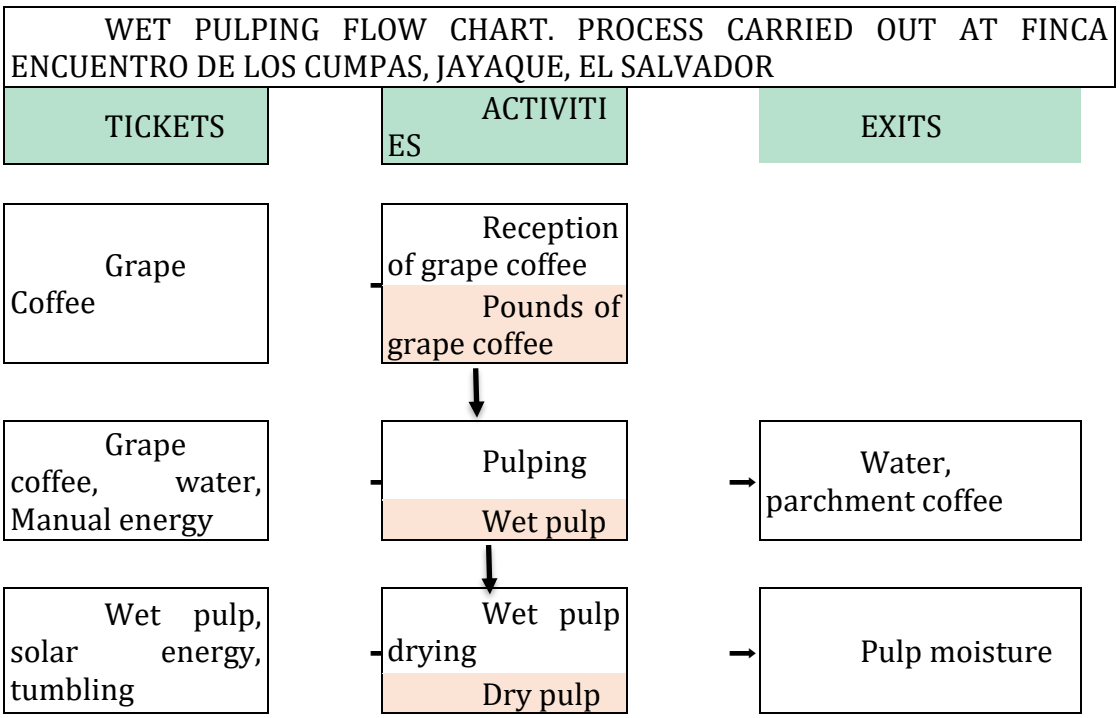
This study was carried out in collaboration with two farms located in the department of La Libertad, El Salvador, where the two drying processes were carried out independently and then compared to determine which one provided the best pulp yield.

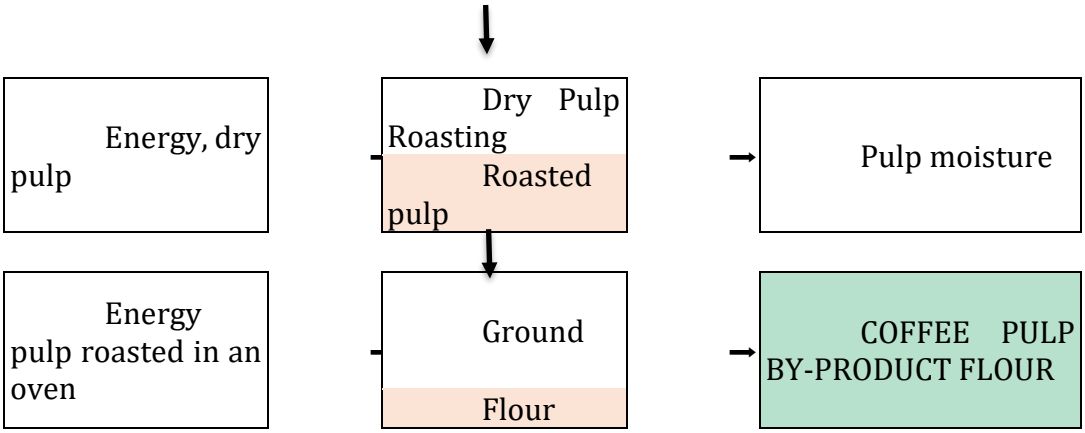
Encuentro de los Cumpas Farm

The farm is located in the municipality of Jayaque, department of La Libertad, at 998 meters above sea level. Where a manual pulper "IDEAL ANTIOQUEÑA" is used to separate the husk of the coffee grapes (pulp) and extract the almonds that are used for the traditional beverage. This equipment is supplied with coffee grapes and water through a hopper, and by manually turning the handle, pressure is exerted that suctions the grain and separates the kernel from the by-product as the inputs pass through the gear. For this research, the by-product (pulp) was collected in sacks and handled to ensure its safety, since it is later used as raw material for a flour suitable for human consumption. The following flow chart is derived from the applied process (Figure 1)

Figure 1

Diagram of the wet pulping process. It is used to separate or remove the shell from the coffee fruit and extract the kernel





Each activity is described with its inputs and outputs. Own elaboration.

The above figure coincides with the sequence shown below:

A total of 1750 pounds of coffee grapes were received, separating it into 15 observations, of which 14 of 115 pounds each were taken, leaving out a lot of 140 pounds; With the wet pulping machine, the grape coffee was processed to separate the bean from its coating.

The pulp is dried in the sun with constant turning for 15 days, generating the dried by-product;

This pulp was transported for medium dark roasting;

Passage through industrial mill;

Flour production.

Figure 2 shows each of the stages of the process, from the cutting of the coffee until the flour is obtained.

Figure 2

From the cutting of the coffee plant and the use of a mechanical pulper to the production of coffee pulp flour

ELABORATION OF FLOUR FROM COFFEE PULP BY-PRODUCT AT EL ENCUENTRO DE LOS CUMPAS JAYAQUE FARM

COFFEE SHORT

In El Salvador, this operation begins in October and usually lasts until May and June of the following year.

At the Encuentro de los Cumpas farm, the maturity of the coffee fruit is determined by the changes in color from green to yellow to crimson red, and by a change in the consistency of the pulp from hard to soft.

At this last stage, the fruit is cut by hand by knowledgeable people who visually determine the right point to remove the fruit from the bush.

OBTAINING GRAPE COFFEE

Grape coffee is understood to be the fruit cut from the coffee bush during harvesting on the farm.

The fruits are harvested in containers, and then transferred to sacks to facilitate transport and handling.

On the farm, the coffee that is harvested is pulped the same day, as they consider that careless piling accelerates fermentation processes that would damage the fruit.

MECHANICAL PULPING

Pulping is carried out by means of a machine that separates the coffee bean (product) from the pulp (by-product); the latter being the input for this research.

This operation consists of extracting the pulp or epicarp from the grain with a machine called a pulper, as described below:

Washing and immersing the grains in water to remove the grains that have little weight (immaturity or damage index).

The grains are fed into the machine, which sucks the grains by means of rollers that will exert mechanical pressure as the pulper cylinder is manually rotated.

Water is added to the hopper, which, by soaking the contents, contributes to the conduction of pulp and coffee.

Finally, whole coffee beans are obtained separated from the pulp. The latter is used as an input in this research, as opposed to the disposable by-product treatment it is generally given.

SUN DRYING OF WET PULP

For the development of this research, we proceeded as follows:

Washing of the pulp, for which a 200 ppm chlorine solution is prepared, obtained from a commercial chlorine at a concentration of 6%, diluting 5 ml per gallon of water.

Rinsing the pulp to remove any residual chlorine

Drained to dry it for the necessary time to lose humidity and taking advantage of the sun as a natural resource.

The parameter that is observed is the color change, which goes from crimson red on day one, and changing to brown (coffee) on day 21.

After a few days, a manual test is carried out to check if the pulp pulverizes easily.

STOVE ROASTING

Oven roasting is a unitary operation that serves:

To finish extracting moisture until a medium dark roast is achieved, which are the characteristics desired for the pulp.

To eliminate biological risks by destroying microorganisms, complying with the time-temperature binomial where baking exceeds 70º C where pathogens are destroyed, being maintained at 250º C for 2 hours.

Ground

Unit operation used to reduce the size of the dry pulp until it is pulverized. This is a fine milling process to obtain flour characterized by its easy mixing with any other type of edible sifted material to make cookies, bread, pasta, among others.

Flour production 	Powder resulting from the grinding of dry pulp that can be used for human and/or animal consumption

La Sierra de León Farm

Finca La Sierra de León is located in the municipality of Huizúcar, department of La Libertad, at 640 meters above sea level in El Salvador. In this environment, the drying of the coffee grapes in patios was experimented in order to later be threshed. The process followed the sequence described below:

-1750 pounds of coffee grapes were received, separating it into 15 observations, of which 14 of 115 pounds were taken, leaving out 140 pounds (lost value);

-The grape coffee was dried, for 21 days, directly in the sun until it was transformed into cherry coffee;

-After 21 days, the coffee beans were threshed to separate them from the pulp (by-product) using a threshing machine.

-The pulp obtained by threshing was collected immediately and carefully deposited in clean sacks. Since it is the input for the process being considered, it was handled as raw material: keeping it safe so that the flour does not involve any physical, chemical or biological risk.

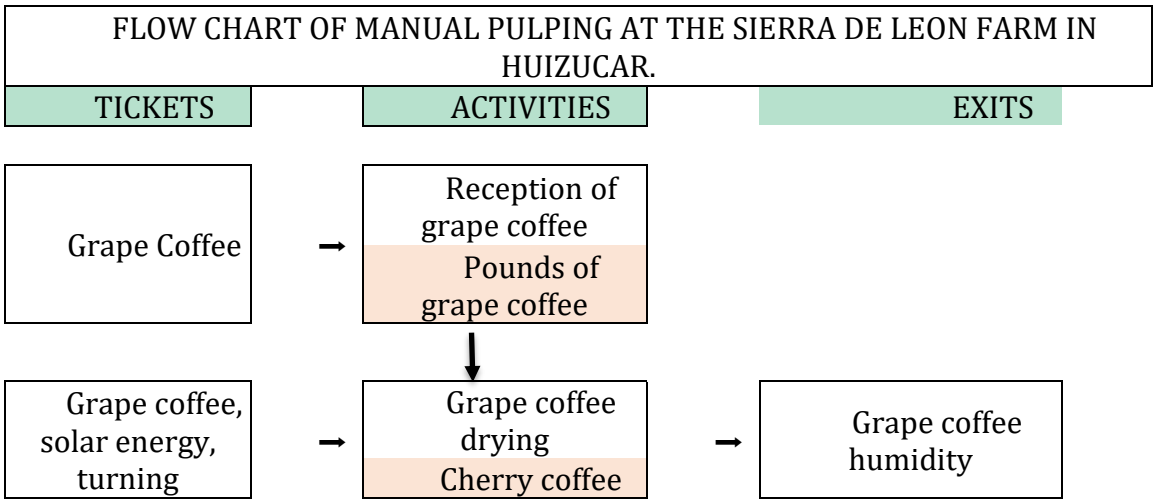
-The bags were transported to the roasting station where the pulp was exposed to heat until a medium dark finish was achieved, which, in addition to facilitating the grinding stage, maintains the caffeine with greater sweetness than a completely dark roast. Temperature is used as a contributor to safety.

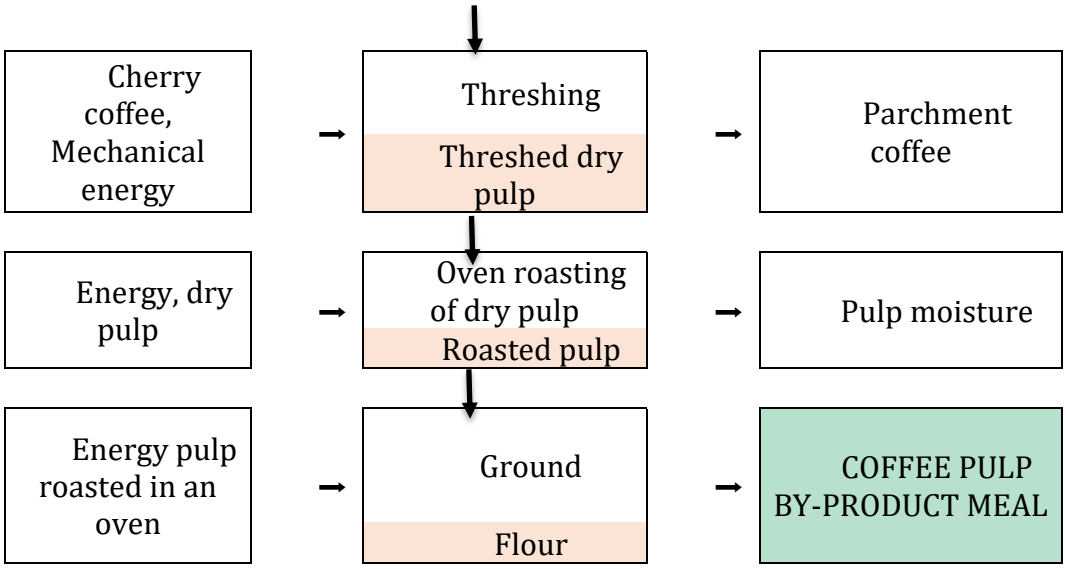
-The roasted pulp was passed through an industrial mill to obtain flour.

Figure 3 shows the flow diagram for pulping by threshing machine.

Figure 3

Flow chart for pulping with threshing machine





Each activity is described with its inputs and outputs. Own elaboration.

In order to facilitate the understanding of the process, Figure 4 is included; in which each of the stages of the process from the cutting of the coffee to the obtaining of the flour are observed.

Figure 4

Processing of flour by-product of coffee drying using a threshing machine

PREPARATION OF FLOUR FROM COFFEE PULP BY-PRODUCT AT THE SIERRA DE LEÓN FARM LOCATED IN HUIZÚCAR

COFFEE SHORT

The coffee is harvested manually, selecting the ripe fruit and leaving the rest for 15 to 30 days;

- The ripe fruits are cut with care not to damage the plant or the delayed harvest;
- The cutting task on this farm is carried out by people trained in the selection of the grain suitable for the subsequent stages.

COFFEE DRYING TO CHERRY

In this method the drying is done directly on the cement; the grain is spread in layers whose thickness is calculated between 3.50 and 3.55 centimeters, stirring constantly from 3 to 5 times per day.

During the night or periods when there is no sun, the deployment is covered with plastic sheeting.

Drying lasts from 10 to 21 days, and 3 aspects are taken into account for testing:

- When a sample is kicked it peels off the shell easily. (pulp is released);
- When bitten, it feels hard;
- The color change on day one is red and yellow grains, until they turn into a dark brown.

The coffee is collected in sacks that are neatly stowed to be transported to the threshing machine

THRESHOLDING

Threshing is the operation in which, after drying, the grain is separated from the dry pulp known as husk.

The final objective of the process is to obtain the grain. This research extends its purpose to processing the by-product (pulp) obtained from threshing.

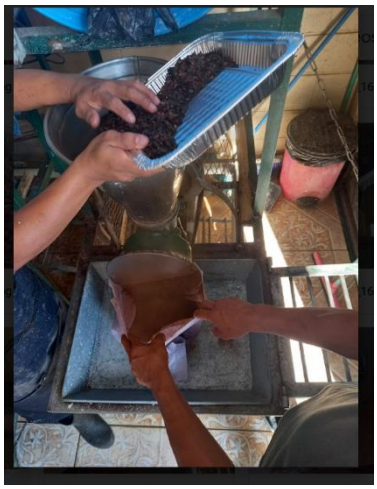
SUBPRODUCT

The by-product is treated as agricultural waste; despite being rich in bioactive compounds such as polyphenols, alkaloids, proteins, chlorogenic acids, dietary fiber, carbohydrates, and antioxidants.

STOVE ROASTING

Stove roasting is carried out until the application of heat allows the pulp to reach a dark brown color.

Ground



The desired finish was achieved in the oven at a temperature of 250º C, for a period of 2 hours.

The grinding operation was carried out in an industrial electric mill.

Finally, it was possible to obtain a flour suitable for human consumption and usable in combination with another food sift.

The flours obtained from the two processes discussed above were exposed to moisture tests on a dry basis in triplicate, using the moisture analyzer programmed with standard drying profile at a temperature of 120°C and in the automatic drying determination mode (mass change per 1 mg/d for 60 s).

The intervening factors were the raw materials and the appropriate equipment to measure humidity; according to detail:

- Experiment 1 samples. Wet pulping process.
- Experiment 2 samples. Process used: Dry pulping during threshing.
- RADWAG® moisture analyzer of the MAC 50/WH series. Laboratory equipment for measuring the relative humidity of samples of different materials.

Procedure

The samples of the different stages of the processes used were arranged in triplicate; they were stored at room temperature in plastic bags to be transported to the point where they would be analyzed.

The moisture content of the samples was determined in triplicate using the RADWAG Analyzer. The equipment was programmed with standard drying profile at 120º C and in automatic determination mode.

Subsequently, the data were recorded in order to obtain their averages.

Results (14 points)

The database generated for the two experiments to collect data were as follows: Table 1 shows a consolidated summary of the results obtained considering the two drying methods.

Table 3

Comparison between the two drying methods used

Place of coffee production	Meeting of the Cumpas	The Sierra de León
Pounds of initial coffee	1610 lbs	1610 lbs
Meters above sea level at which the coffee was harvested.	998 meters above sea level.	640 m.a.s.l.
Pulping method	With machine after cutting	Separated after drying and threshing
Obtaining by-product (pounds of pulp)	685 lbs. wet pulp obtained with pulper	310 pounds of threshing
Dry pounds	350 lbs	310 lbs
% dry by-product	20%	17.71%

Oven-roasted by-product	260 lbs	220 lbs
Flour production	150 lbs	110 lbs

Each of the raw materials in the different activities of the process were characterized according to the milestone to which they correspond, in order to justify drying as a method of conservation and stabilization, since the pulp, being dry, avoids the proliferation of microorganisms, molds and yeasts that would be present in an aqueous environment. The humidity results are presented below.

Humidity results of the jayaque experiment "finca el encuentro de los cumpas"

UVA COFFEE						AVERAGE	
	M1		M2		M3		UNIT
INITIAL WEIGHT	5,644	g	5,347	g	5,936	g	5,64233333	g
FINAL WEIGHT	1,765	g	1,983	g	2,011	g	1,91966667	g
TOTAL TIME	2:18 a.m.	h:min:sec	1:33 a.m.	h:min:sec	2:48 a.m.	h:min:sec	2:14:20 a.m.	h:min:sec
% HUMIDITY WET BASIS	68,728	%	62,913	%	66,121	%	65,92066667	%
% HUMIDITY DRY BASIS	21 9,773	%	16 9,64	%	19 5,176	%	194,863	%
ANALYSIS TEMPERATURE	120	°C	120	°C	120	°C	120	°C

WET LUNG						AVERAGE	
	M1		M2		M3		UNIT
INITIAL WEIGHT	5,904	g	5,001	g	2,604	g	4,503	g
FINAL WEIGHT	1,203	g	1,064	g	0,605	g	0,9573333	g
TOTAL TIME	1:03:36 a.m.	h:min:sec	12:57:49 a.m.	h:min:sec	1:06:03 a.m.	h:min:sec	1:02:29 a.m.	h:min:sec
% HUMIDITY WET BASIS	79,624	%	78,724	%	76,766	%	78,371333	%
% HUMIDITY DRY BASIS	39 0,773	%	37 0,019	%	33 0,413	%	363,735	%

ANALYSIS TEMPERATURE	120	°C	120	°C	120	°C	120	°C

BY-PRODUCT (PULP DRIED 12 DAYS) WITHOUT STOKER							AVERAGE	
	M1		M2		M3		UNIT	
INITIAL WEIGHT	2,583	g	2,887	g	2,618	g	2,696	g
FINAL WEIGHT	2,409	g	2,682	g	2,441	g	2,5106 66667	g
TOTAL TIME	12:21:25 a.m.	h:min:sec	12:22:05 a.m.	h:min:sec	12:21:20 a.m.	h:min:sec	12:21:37 a.m.	h:min:sec
% HUMIDITY WET BASIS	6,664	%	7,101	%	6,761	%	6,842	%
% HUMIDITY DRY BASIS	7,139	%	7,643	%	7,251	%	7,3443 33333	%
ANALYSIS TEMPERATURE	120	°C	120	°C	120	°C	120	°C

MEDIUM DARK ROASTED BY-PRODUCT							AVERAGE	
	M1		M2		M3		UNIT	
INITIAL WEIGHT	2,195	g	2,217	g	2,597	g	2,3363 33333	g
FINAL WEIGHT	2,169	g	2,186	g	2,562	g	2,3056 66667	g
TOTAL TIME	12:04:03 a.m.	h:min:sec	12:04:50 a.m.	h:min:sec	12:05:10 a.m.	h:min:sec	12:04:41 a.m.	h:min:sec
% HUMIDITY WET BASIS	1,185	%	1,354	%	1,31	%	1,283	%
% HUMIDITY DRY BASIS	1,198	%	1,372	%	1,327	%	1,299	%
ANALYSIS	120	°C	120	°C	120	°C	120	°C

TEMPERATURE									

BY-PRODUCT MEAL							AVERAGE	
	M1		M2		M3		UNIT	
INITIAL WEIGHT	5,073	g	5,061	g	5,194	G	5,1093333	g
FINAL WEIGHT	4,777	g	4,720	g	4,868	G	4,7883333	g
TOTAL TIME	12:20:56 a.m.	h:m in:sec	12:19:54 a.m.	h:m in:sec	12:21:03 a.m.	h:m in:sec	12:20:38 a.m.	h:m in:sec
% HUMIDITY WET BASIS	5,835	%	6,737	%	6,276	%	6,2866667	%
% HUMIDITY DRY BASIS	6,196	%	7,224	%	6,697	%	6,7056667	%
ANALYSIS TEMPERATURE	120	°C	120	°C	120	°C	120	°C

Humidity results of the huizucar experiment "finca de léon"

UVA COFFEE							AVERAGE	
	M1		M2		M3		UNIT	
INITIAL WEIGHT	6,310	g	6,300	g	6,109	g	6,2396667	g
FINAL WEIGHT	2,116	g	1,802	g	2,019	g	1,979	g
TOTAL TIME	2:18:23 a.m.	h:m in:sec	2:20:16 a.m.	h:m in:sec	2:19:54 a.m.	h:m in:sec	2:19:31 a.m.	h:m in:sec
% HUMIDITY WET BASIS	66,466	%	71,396	%	66,950	%	68,270667	%
% HUMIDITY DRY BASIS	198,204	%	249,611	%	202,575	%	216,79667	%
ANALYSIS TEMPERATURE	120	°C	120	°C	120	°C	120	°C

CHERRY COFFEE 10 DAYS							AVERAGE	
	M1		M2		M3		UNIT	
INITIAL WEIGHT	4,739	g	5,587	g	4,741	g	5,02233333	g
FINAL WEIGHT	4,477	g	5,325	g	4,479	g	4,76033333	g
TOTAL TIME	12:59:05 a.m.	h:min:sec	12:57:56 a.m.	h:min:sec	12:59:03 a.m.	h:min:sec	12:58:41 a.m.	h:min:sec
% HUMIDITY WET BASIS	5,5	%	4,6	%	5,5	%	5,241333333	%
% HUMIDITY DRY BASIS	5,829	%	4,920	%	5,849	%	5,532666667	%
ANALYSIS TEMPERATURE	120	°C	120	°C	120	°C	120	°C

BY-PRODUCT (THRESHED PULP) (WITHOUT STOVE)							AVERAGE	
	M1		M2		**M3**		UNIT	
INITIAL WEIGHT	3,018	g	3,045	g	2,875	g	2,979333333	g
FINAL WEIGHT	2,682	g	2,712	g	2,562	g	2,652	g
TOTAL TIME	12:23:15 a.m.	h:min:sec	12:21:50 a.m.	h:min:sec	12:21:00 a.m.	h:min:sec	12:22:02 a.m.	h:min:sec
% HUMIDITY WET BASIS	11,104	%	10,848	%	10,887	%	10,946333333	%
% HUMIDITY DRY BASIS	12,490	%	12,168	%	12,217	%	12,291666667	%
ANALYSIS TEMPERATURE	120	°C	120	°C	120	°C	120	°C

MEDIUM DARK ROASTED BY-PRODUCT							AVERAGE	
	M1		**M2**		M3		UNIT	
INITIAL WEIGHT	2,858	g	3,096	g	3,090	g	3,014666667	g

FINAL WEIGHT	2,799	g	3,030	g	3,025	g	2,95133333	g
TOTAL TIME	12:07 a.m.	h:min:sec	12:08 a.m.	h:min:sec	12:08 a.m.	h:min:sec	12:08:03 a.m.	h:min:sec
% HUMIDITY WET BASIS	1,996	%	2,132	%	2,072	%	2,06666667	%
% HUMIDITY DRY BASIS	2,036	%	2,178	%	2,115	%	2,10966667	%
ANALYSIS TEMPERATURE	120	°C	120	°C	120	°C	120	°C

	BY-PRODUCT MEAL						AVERAGE	
	M1		M2		M3		UNIT	
INITIAL WEIGHT	5,219	g	5,061	g	5,071	g	5,117	g
FINAL WEIGHT	4,874	g	4,718	g	4,733	g	4,775	g
TOTAL TIME	12:25:10 a.m.	h:min:sec	12:19:50 a.m.	h:min:sec	12:19:25 a.m.	h:min:sec	12:21:28 a.m.	h:min:sec
% HUMIDITY WET BASIS	6,666	%	6,732	%	6,632	%	6,67766667	%
% HUMIDITY DRY BASIS	7,146	%	7,218	%	7,110	%	7,15533333	%
ANALYSIS TEMPERATURE	120	°C	120	°C	120	°C	120	°C

After studying moisture throughout the process, the quantitative yields in pounds of the two alternative methods were examined. The data were recorded and tabulated in the SPSS® statistical program, version 22, and then a t-test was performed to compare means between independent samples.

Table 1

Experiment 1. Jayaque manual pulper and pulp dryer treatment

ACTIVITIES/COMMENTS	OBSERVATION 1	OBSERVATION 2	OBSERVATION 3	OBSERVATION 4	OBSERVATION 5	OBSERVATION 6	OBSERVATION 7	OBSERVATION 8	OBSERVATION 9	OBSERVATION 10	OBSERVATION 11	OBSERVATION 12	REMARK 13	REMARK 14	REMARK 15	TOTAL POUNDS
UVA COFFEE	115	115	115	115	115	115	115	115	115	115	115	115	115	115	1405	1750
WET PULP BY-PRODUCT	4,960	5,120	5,080	4,910	5,230	5,370	5,140	5,260	5,030	5,100	4,940	5,210	5,060	5,030	3,560	85,000
BY-PRODUCT SUN-DRIED PULP WITHOUT AN OVEN	22,972	23,054	23,034	22,947	23,110	23,182	23,064	23,126	23,008	23,044	22,962	23,102	23,023	23,008	7,366	350,000
BY-PRODUCT KILN DRIED PULP	11,065	11,126	11,111	11,046	11,168	11,221	11,133	11,179	11,092	11,118	11,058	11,160	11,103	11,092	10,329	160,001
FLOUR	99,845	99,880	99,872	99,834	99,904	99,935	99,885	99,911	99,861	99,876	99,841	99,900	99,867	99,861	1,728	1450,000

Table 2

Experiment 2. Sun-dried and threshed to obtain pulp

ACTIVITIES/COMMENTS	OBSERVATION 1	OBSERVATION 2	OBSERVATION 3	OBSERVATION 4	OBSERVATION 5	OBSERVATION 6	OBSERVATION 7	OBSERVATION 8	OBSERVATION 9	OBSERVATION 10	OBSERVATION 11	OBSERVATION 12	REMARK 14	REMARK 15	TOTAL POUNDS
UVA COFFEE CHERRY COFFEE (SUNNY PATIOS) IN	115	115	115	115	115	115	115	115	115	115	115	115	115	1405	1750,000
	42,810	42,620	42,760	42,670	42,800	42,820	42,730	42,670	42,690	42,650	42,710	42,790	42,770	18,330	650,000

BY-PRODUCT THRESHED PULP WITHOUT STALENESS	2 0,417	2 0,326	2 0,393	2 0,350	2 0,412	2 0,422	2 0,379	2 0,350	2 0,360	2 0,341	2 0,369	2 0,408	2 0,355	2 0,398	2 4,719	3 10,000
BY-PRODUCT KILN DRIED PULP	1 4,490	1 4,425	1 4,473	1 4,442	1 4,486	1 4,493	1 4,462	1 4,442	1 4,449	1 4,435	1 4,456	1 4,483	1 4,446	1 4,476	1 7,542	2 20,001
FLOUR	7 ,245	7 ,213	7 ,236	7 ,221	7 ,243	7 ,246	7 ,231	7 ,221	7 ,224	7 ,218	7 ,228	7 ,241	7 ,223	7 ,238	8 ,771	10,000

Table 4

Group Statistics

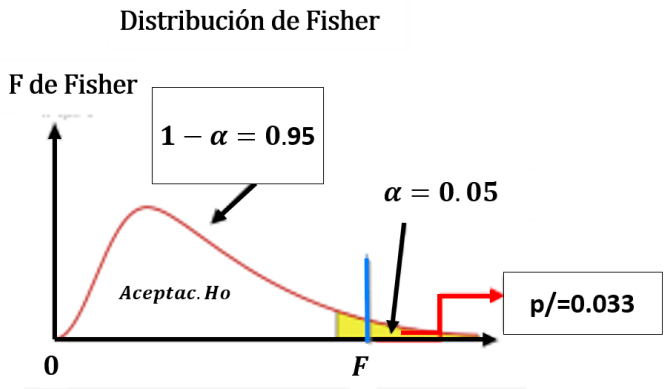
TREATMENT		N	MEDIA	STANDARD DEVIATION	AVERAGE OF STANDARD ERROR
Pulping	Initial pulping (wet)	14	23.0453	.06684	.01786
	Pulping at threshing (dry)	14	20.3772	.03117	.00833

The above table shows that, in pounds, a lower average by-product is obtained by the process in which the pulp is released dry during threshing. The standard deviations indicate that in both processes the observations tend to concentrate around the mean; that is, we have consistent performance in both pulping methods.

1. TEST OF EQUALITY OF VARIANTIES (Levene's test)

Levene's test is an integral part of the battery of results that SPSS produces when running a t-test for comparison of means. The purpose of the test is to determine whether the groups under study have equal variances. It is widely used because many statistical tests use the assumption that groups have equal variances. We start with the following hypothesis:

Ho: Variances of the 2 treatments are equal ($\sigma^2_1 = \sigma^2_2$)
H1: The variances of the two treatments are different. Treatment 1 is more variable than treatment 2 ($\sigma^2_1 > \sigma^2_2$)



As the p-value of the test: p = 0.033 < α = 0.05 , it is observed that it falls in the Rejection zone, therefore the differences observed between the Variances are significant; therefore the null hypothesis of equality in the variances is rejected, since at the given significance level (α = 0.05) the variability of Treatment 1 is greater than that of Treatment 2.

2. TEST OF EQUALITY OF MEANS (Student's t-test)

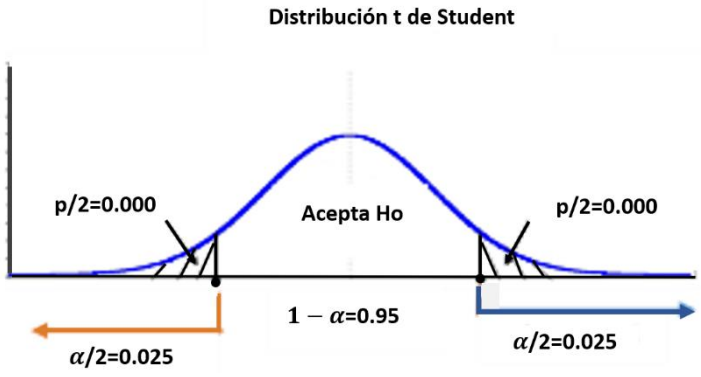
Hypothesis Statement

Ho: The means of the 2 treatments are equal ($\mu_1 = \mu_2$)
H1: Means of the two treatments are different ($\mu_1 \neq \mu_2$)

The data was recorded and processed with SPSS software version 22, obtaining the following results:

INDEPENDENT SAMPLES TEST.

		Levene's test for quality of variances		T-test for equality of means						
									95% confidence interval of the difference	
		F	Sig.	t	gl	Sig. (bilateral)	Difference from stockings	Standard error difference	Inferior	Superior
Dried Pulp	The following are assumed variances Equal	5.067	.033	35.135	1 26	.000	2.66804	0.1971	2.62752	2.70855
	Equal variances are not assumed			135.35	18.398	.000	2.66804	0.1971	2.62669	2.70938



The row corresponding to non-equal variances is taken: As the p-value of the test: p = 0.000 < α = 0.05 , falls in the rejection zone, it indicates that the differences observed between the means are significant; that is, there is statistical evidence at the significance level α = 0.05, that the mean μ1 = 23.0453 is greater than μ2 = 20.3772; that is, the difference of 2.668 in favor of Treatment 1 is significant

From these results it can be established:

- Levene's test for equality of variances results in 0.033; therefore, since it is less than the significance value (alpha 0.05), the null hypothesis (Ho) of equality is not accepted, which implies that equal variances between treatments are not assumed.
- Since equal variances are not assumed, the bilateral significance test results in 0.00, which is less than the 0.05 granted to the alpha value; therefore, Ho (equality of means) is not accepted; and the alternative hypothesis (H1) is concluded: difference of means.
- That is, with a 95% confidence interval percentage, and significance at the 0.05 level, the average yield in pounds is different when comparing the result of one drying process versus the other.
- The sun-dried pulp by-product without an oven was on average 2.66 pounds greater for each 115 pound block of coffee subjected to this process with respect to the same amount subjected to the threshed pulp by-product procedure without an oven.

Discussion and Conclusions

The results of this research show that it is technically feasible to produce flour from the pulp of coffee harvested in El Salvador, at different heights, and regardless of the pulping method; although the dry method yields lower pounds. Previous work demonstrated the usefulness of the pulp in the manufacture of honey and a flour of similar characteristics.

Either wet or dry pulping would not require additional investment beyond what is already in place. Eliminating moisture through drying prevents deterioration of the pulp, maintaining its shelf quality as a raw material for a longer period of time than if it is left wet, as it tends to ferment and decompose at an accelerated rate. This has been verified by researchers such as Zactiti in 2004 and Ventura-Cruz in 2019.

Efforts to maintain pulp safety and quality could translate into alternatives to generate economic flows for producers and contribute to food security.

Prada and its associated researchers, in 2019 addressed the effectiveness of solar dryers with continuous airflow system applied to coffee drying, which undoubtedly accelerates the process. However, the traditional way has also shown favorable results. It will be a matter of available technology and market conditions that will tip the balance in favor of one of the two visions.

The awareness of sustainable production needs to be extended to the creation of consumption alternatives that contribute to natural resources and the environment. Torres' research corroborates that the use of coffee pulp reduces environmental impact and highlights the nutritional benefits it contains.

As a result of the work carried out, it was possible to establish the feasibility of making flour from coffee pulp, which is traditionally treated as a by-product that is discarded, and which entails environmental impacts, transportation and disposal costs. Taking advantage of coffee pulp implies an opportunity to expand the production chain, generate profits and food alternatives.

Regarding the amount of pulp obtained, it was found that, with a manual pulper and subsequent sun drying, a higher yield is obtained than with the process in which the coffee is first dried and then the pulp is obtained by threshing. In the case of the present study, 2.66 pounds more sun-dried pulp was obtained per 115-pound block than that obtained by stoving and threshing. The difference in performance is statistically significant.

From the application of the pulping methods, it was observed that the appearance of the flour is independent, i.e., applying one or the other method does not change the appearance and consistency of the flour

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