

Reuse of coffee waste in the region of Huautla of Jimenez, Oaxaca

Alba Viviana Hernandez Diaz, M.E. Luis Antonio Pereda Jiménez, IBQ. Sandra Melina Rodriguez Valdez, M.A. Maria Deysi Tapia Alvarez

¹ Industrial Engineering Student

^{2, 3, 4} TecNM Industrial Engineering
Division/Ajalpan Campus

Summary.

The country is currently under attack by two major problems, the first is the increase in environmental damage that human activities have caused to the planet, the second problem is that according to data from the Food and Agriculture Organization of the United Nations; Mexico ranks first in overweight and obesity, being alarming since as time goes by the figures are increasing. This work arises from the idea of a solution to these two problems by creating whole foods with a new type of fiber from coffee, which help avoid diseases caused by overweight and obesity, such as cardiovascular diseases, according to statistics are the leading cause of death in the world.

The elaboration of these foods, give rise to the reuse of a waste (parchment), significantly reducing the environmental impact that it generates, the project is developed in the region of Huautla de Jiménez, Oaxaca, with the Organization called "Regional Union of Coffee Growers of the Mazateca Alta", an organization that is dedicated to the management with coffee farmers, the results obtained are focused on the production of bread and the investment plan applied to the product.

Key links: Reuse, coffee, fiber, health, ecological.

Abstract.

The country is currently attacked by two major problems, the first is the increase in environmental damage that human activities have caused to the planet, the second problem is that according to data from the United Nations Food and Agriculture Organization; Mexico ranks first in overweight and obesity, being an alarming problem since as time passes the figures are increasing. This investigation arises from the idea of one solution to these two problems,

by creating whole-grain foods with a new kind of fiber from coffee, which help prevent diseases that are caused by overweight and obesity, such as cardiovascular diseases, that according to statistics are the leading cause of death in the world.

The elaboration of this whole-grain foods, give reason to the reuse of what was originally considered a waste (pergamino), significantly reducing environmental impact that this waste generating, the project is developed in the Huautla de Jiménez region, Oaxaca, with the Organization called "Unión Regional de Cafecultores de la Mazateca Alta", an organization dedicated to managing coffee with farmers. The results obtained are focused on the production of bread and the investment plan applied to the product.

Keywords: Reuse, coffee, fiber, health, ecological.

I. INTRODUCTION

Actualmente, México ocupa el lugar número 11 a nivel mundial de producción de café, una actividad que es considerada una fuente de trabajo que proporciona alrededor de 3 millones de empleos, de acuerdo a los datos del Ministerio de Agricultura y Desarrollo Rural. La comercialización del café ha llevado a su reconocimiento como uno de los principales productos del sector agrícola y uno de los primeros generadores de empleo en el sureste del país, por lo que el uso de uno de sus residuos es importante para el medio ambiente, también creando un nuevo producto de café.

II. OBJECTIVES

General objective.

Reuse parchment coffee residues generated in the process of cleaning it.

Specific objectives.

- Conduct the necessary investigations of the benefits of the type of coffee planted in the Huautla region in order to establish a by-product and the way of processing it.
- Perform the appropriate pruebas with the husk.
- Prepare a market study and technical study of the production process of the selected by-product.
- Make a business plan to obtain profitability parameters.
- Develop the implementation plan for the solution proposal.

III. JUSTIFICATION

Take advantage of the amount of parchment coffee residues generated in the process of cleaning it. This allows to obtain by-products based on the husk, which generates results with antioxidant properties and also seeks to be offered in the city market. All this decreases the amount of discarded husk that over time reaches rivers and lakes causing serious environmental problems due to the concentration of CO₂ and methane that originates from contact with other substances, providing in turn a further income to the company with the commercialization of a new product.

IV. METHODOLOGY OF RESEARCH

A. Research focus

The research work has a descriptive approach because it seeks to explain situations of activities of people, groups, communities through analysis, on an important aspect, such as coffee residue. It is a study that allows to describe what is investigated for a case study, such as the use of coffee waste.

B. Type of research

Descriptive quantitative research design; quantitative research helps to improve products or make accurate and informed decisions that help achieve the established objectives.

In general, it is about asking people to give their opinion in a structured way to be able to produce statistical data that guide and in this way, obtain good results.

C. Research design.

The design of the research is of a quantitative nature which is considered of great importance for the growth of any organization, since any conclusion based on numbers and analysis will be effective for the implementation of the project.

V. DEVELOPMENT OF THE PROPOSAL.

"Regional Union of Coffee Growers of the Mazateca Alta" URCAMA, is a company dedicated to marketing coffee, its process is to acquire "parchment coffee" (dried beans with husk), perform the cleaning process to obtain and later sell "gold coffee" (beans ready to roast).

According to company data, for every 1000 grams of parchment coffee, approximately 250 grams of husk are obtained. This waste is stored inside the company in bags of 50 kg each. Generally this residue is used by farmers as fertilizers for the same plants of café, as well as for the sowing of corn and beans. In addition, they pour them into land to fertilize the land.

This residue, when dumped on the ground, has a degradation time of approximately two months, depending on the type of soil and climatic conditions. The area in which this problem develops is a mountainous region where heavy rains occur most of the year, so the water that runs through the hills tends to carry this waste, crossing it through the slopes of the mountains reaching rivers, lakes and dams nearby. As the husk is an insoluble element, it remains almost intact in the water and when in contact with pollutants it causes concentration of carbon and methane, causing damage to the atmosphere.

VI. CONCEPTUAL FRAMEWORK.

As the main reference is described the work that corresponds to [1] of the department of biology of the University of Trieste, who carried out a study on the possible alternative uses of waste and

coffee by-products. Which propose the following uses and repercussions:

- Biogas from coffee wastewater.
- Solids of coffee pulp for silage.
- Mushrooms.
- Coffee husk as fuel.
- Coffee mucilage.
 - Natural sugars from coffee fruit.
 - Antioxidant and flavonoid compounds.
 - Dietary insoluble fiber: Atherosclerosis arises when the arteries are loaded with cholesterol deposits (i.e., low-density lipoproteins). Of paramount importance in that regard are the coronary arteries and the danger of a heart attack. Coffee pectins also raise the level of high-density lipoproteins, which are the beneficial ones. It is well known that pectins enclose bile acids (where those cholesterol come from) and carry them through the small intestine to the large intestine or colon, where some of them become food for bacteria, which in turn protect against colon cancer.
 - Fat substitute.

One more reference is the work of [2] from the Universidad La Gran Colombia, who carried out a study on the use of coffee pulp as an alternative for the valorization of by-products, with the following methodology: Raw material and preparation of extracts; We worked with coffee pulp, an orange castle variety supplied by producers in the department of Risaralda, Colombia. The coffee pulp was dried to 60

°C for 420 minutes using a forced circulation stove (Binder, Germany). Drying conditions were established experimentally based on moisture content (data not presented). Subsequently, 3.3 grams of dried coffee pulp were taken and placed on a filtrante cloth. The pulp was immersed in 250 ml of drinking water (used as a solvent).

And finally you have [3] from the Autonomous University of the State of Mexico, who conducted a study to characterize the solid waste generated in the laboratory and in a restaurant of traditional Mexican cuisine, to develop proposals for reuse, such as gastronomic use. Work in which he mentions the importance of reusing the organic waste generated in establishments where food is handled, this in order to reduce the amount of garbage.

A. Type of coffee: Arabica or Arábica.

This type of coffee is from the south of Ethiopia, it is the type of grain that conquers up to almost 80% of the world's production. In the first years of its cultivation only its leaves were used for the preparation of tea.

The caffeine concentration of these grains, characterized by being clear and large, is 1-1.5%, which is a low value. Its flavor is mild and pleasant to the palate, sometimes reminiscent of wild aromas and nuts, even acidic touches. Arabica coffee is considered gourmet type.

Classification: Criollo or Typica is the best adapted to the territory of southern Mexico and one of the best varieties. It is harvested under shade and offers an exquisite flavor with accentuated acidity.

The Huautla region is distinguished by being cold and humid, with a height between 1800 and 2200 meters above sea level. The main activity is agriculture, among which the cultivation of coffee stands out mainly; that due to the topological conformation of the area the so-called "high altitude coffee" is obtained which is called in this way by the area in which it is cultivated, highlighting that the taste is different from the types of coffee grown in other regions.



Fig. 3. Creole Arabica coffee plant.

B. Chemical composition of parchment or coffee husk

The parchment is one of the two layers that coats and protects the coffee bean, pale yellow and of hard and fragile consistency when it has dried, it is located between the mucilage (mesocarp) and the silver film (seminal integument). Due to the amount it represents by weight, it is the waste that contributes the highest percentage of pollution to the global balance, therefore,

it is considered a great source of research in the manufacture of new coffee by-products.

	Ashes (%)	Protein (%)	Fiber (%)	ELN (%)	Ethereal extract (%)
PARCHMENT	3.6	5.9	68.6	20.3	1.3

Fig. 1. Chemical composition Of parchment [4]

68.6% of the husk that is considered fiber is made up of the following:

- 3-7 layers of sclerenchyma cells: supporting tissues of some plants formed by cells dead at maturity whose secondary walls are thickened and hardened. is an elastic fabric. the compound that gives it its cellular characteristics is lignin.
- Cellulose: biopolymer composed exclusively of β -glucose molecules (from hundreds to several thousand units), as it is a homopolysaccharide. Cellulose is the most abundant organic biomolecule as it forms most of the earth's biomass. Cellulose is formed by the binding of β -D-glucose molecules by β -1,4-Oglucosidic bonds. When totally hydrolyzed, glucose is obtained. Cellulose is a long polymer chain of wadable molecular weight, with empirical formula $(C_6H_{10}O_5)_n$ with a minimum value of $n = 200$. It has a linear or fibrous structure, in which multiple hydrogen bonds are established between the hydroxyl groups of different juxtaposed glucose chains, making them impenetrable to water, which makes it insoluble in water, and originating compact fibers that constitute the cell wall of plant cells. [5]

C. Fiber

According to the "Official Mexican Standard NOM-043SSA2-2005. Basic health services. Promotion and education for health in food matters. Criteria for providing guidance", dietary fiber is the edible part of plants or analogous carbohydrates that are resistant to nutritionand absorption inthe human small intestine and undergo total or partial fermentation in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin, and other plant-associated substances. They are divided into soluble and insoluble. Epidemiologically its insufficient consumption has been associated with the appearance of chronic diseases.

The fiber found in the coffee parchment is of insoluble type which makes it have a hard texture or gruesa, this type of fiber acts more quickly in the fight against constipation.

D. Fiber consumption in Mexico

According to the FAO/WHO Expert Committee, the daily recommendation for total dietary fibre for adults is 25 g/day. The range of recommendations between various countries around the world ranges from 21-40 g/day. In the case of Mexico, nutrition experts have recently published their consumption recommendation for each age range, which is shown in the table below.

	Fiber intake recommendations for population in Mexico (g/day)	
Age group	Men	Women
2-4 years	14	14
5-8 years	18	18
9-13 years	22	22
14-18 years	30	26
19-50 years	35	30
Over 50 years old	30	26

Fig. 2. Recommendation of daily fiber intake [6]

Mexico faces two simultaneous problems in relation to the nutrition of its population; on the one hand, there are still people with malnutrition problems and on the other, a significant segment of its population is overweight and obese. The most recent figures from the National Health Program show that the prevalence of overweight and obesity in Mexican adults increased from 34.5% in 1988 to 69.3% in 2006.

D. Fiber as an important element for the prevention of diseases.

1) Digestive health.

According to [7] depending on the type of diet, food takes between a day and a half to three days to travel the full length of the digestive tract.

Having good digestive health is just as important as maintaining a healthy heart. Digestive health not only helps to avoid constipation but also to the general well-being and proper functioning of the immune system in the digestive tract.

2) Heart health.

In Mexico, mortality from cardiovascular disease predominates among the chronic diseases that today, and

for several decades, they have been among the top three causes of death in the country. [8]

Fiber helps keep the heart healthy because:

- It can reduce the absorption of cholesterol that comes from food and lower LDL ("bad" cholesterol) cholesterol in the blood.
- It can reduce blood pressure.
- Helps with weight control.
- It helps control blood glucose levels.

3) Fiber for diabetes prevention.

According to the Mexican Diabetes Federation, the diabetic population in Mexico fluctuates between 6.5 and 10 million. Of this grand total, 2 million people have gone undiagnosed.

90% of people with diabetes have type 2 of the disease. The percentage of the population suffering from diabetes increases with age. After the age of 50, the prevalence exceeds 20%.

The mechanism of fiber to prevent and control diabetes is through the result of the combination of the effects it has on the body among which the control of body weight and the levels of glucose and insulin in the blood stand out.

4) Fiber for cancer prevention.

Fiber-rich foods tend to be rich in antioxidants, vitamins, and minerals, which in turn have been linked to cancer prevention.

A European study conducted in ten countries, involving more than 500,000 people, suggests that doubling fiber intake (current intake is about 15g per day) could reduce cancer risk of the colon by 40 percent [9]. Fiber alters hormone levels in the body, particularly by reducing the level of estrogen, which has been associated with the risk of breast cancer. [10]

5) Fiber consumption = well-being.

Your current lifestyle can lead to high levels of tiredness or fatigue. Recent research has shown that fiber can help improve energy levels and well-being. Over the course of a study, researchers at the University of Cardiff – in the United Kingdom – found that people who consumed foods with more fiber, had less emotional stress, fewer cognitive difficulties and levels of fatigue lower. The study found that a 10 percent increase in fiber intake over two weeks was linked to increased energy levels and reduced fatigue.

VII. METHOD OF REALIZATION OF THE PROJECT.

The first step was to clean the husk (removing leaves, stones, remains of sack, among others), this because being considered a residue does not take the necessary care for a food in this case.



Fig. 4. Coffee husk.

The next step was to wash the husk to remove dust and other contaminants.



Fig. 5. Husk washing

Subsequently, the container was placed under the sun to remove the water and obtain the husk again in its natural state.

To avoid fermentation, it was determined to remove moisture from the residue at home in a comal, at a temperature of 50°C for a time of 14 to 19 minutes depending on the portion of husk. Once the husk is placed on the comal, slight movements are made with some kitchen utensil, this to prevent the husk from burning, in addition to making all the parts dehydrated equally.



Fig. 6. Process of dehydration of the husk.

Once the residue was dry, the grinding process was carried out in a homemade hand mill, in order to obtain a fine powder that can be easily incorporated into a food and the texture of the fiber does not feel so abrupt when ingested.



Fig. 7. Grinding process of the husk.

Being a hard and thick element, in the first instant it was not so fine, so a sifting process was done with the help of a strainer, and thus separate the parts that have not yet been ground by complete. The procedure was repeated for 3 times.



Fig. 8. Sifting of the powder resulting from grinding.

The amount of husk with which the test was done was 100 grams, once the procedure was finished a total of 50 grams of pure fiber was achieved.



Fig. 9. Final result: pure fiber.

Later it was determined to bake cookies and bread incorporating coffee husk fiber into the flour, to achieve a whole food. Reason why a market study and a business plan were carried out.

[11] explains that the fiber content for the preparation of whole foods should be between 10% and 20% depending on the type of fiber, which defines that it should be added by 20%.

VIII. RESULTS.

URCAMA aims to market whole foods, in addition to pure fiber, all of the above based on coffee husk. The first option consists of individual whole wheat bread (panqué) of 4 different flavors; coffee, chocolate, cinnamon, vanilla. The second option consists of whole grain biscuits, and pure fibre is offered as a last option.



Fig. 10. Whole wheat bread.

In the case of whole grain cookies, like bread, pure fiber is incorporated into wheat flour by 20%. The result is as shown in the following image.



Fig. 11. Whole grain cookies.

The Official Mexican Standard NOM-086-SSA1-1994 Goods and services. Food and non-alcoholic beverages with modifications in their composition. Nutritional specifications s. Establishes in its Article 7.17 that for a food to be considered as added with fiber, its content of this nutrient must be equal to or greater than

2.5 grams per serving, in relation to the content of the original food or its similar.

It should be noted that a portion of whole wheat bread made by URCAMA is equal to 3.6 grams, which complies with the provisions of the standard described above. In the case of cookies, a portion of 2 pieces is enough to meet the standard.

Because the purpose of the company is to market such products, a business plan was made obtaining the following:

ESTADO DE RESULTADOS	Año 1	Año 2	Año 3	Año 4	Año 5
ingresos	\$ 212.335,10	\$ 243.144,92	\$ 278.425,25	\$ 318.824,76	\$ 365.086,23
costo del producto	\$ 97.254,45	\$ 111.366,07	\$ 127.525,28	\$ 146.029,20	\$ 167.218,04
utilidad bruta	\$ 115.080,65	\$ 131.778,86	\$ 150.899,97	\$ 172.795,56	\$ 197.868,19
gastos de administracion y ventas	\$ 84.252,00	\$ 63.996,52	\$ -	\$ -	\$ -
utilidad antes de financiamiento	\$ 30.828,65	\$ 67.782,34	\$ 150.899,97	\$ 172.795,56	\$ 197.868,19
depreciaciones	\$ 4.598,80	\$ 4.598,80	\$ 4.598,80	\$ 4.983,14	\$ 4.983,14
utilidad antes de financiamientos	\$ 26.229,85	\$ 63.183,54	\$ 146.301,17	\$ 167.812,42	\$ 192.885,05
gastos financieros	\$ -	\$ -	\$ -	\$ -	\$ -
utilidad antes del impuesto	\$ 26.229,85	\$ 63.183,54	\$ 146.301,17	\$ 167.812,42	\$ 192.885,05
impuestos	\$ 10.491,94	\$ 25.273,42	\$ 58.520,47	\$ 67.124,97	\$ 77.154,02
utilidad neta	\$ 15.737,91	\$ 37.910,13	\$ 87.780,70	\$ 100.687,45	\$ 115.731,03
rendimiento promedio	7,41%	15,59%	31,53%	31,58%	31,70%

Fig. 12. Income statement of the business plan.

IV. CONCLUSION.

Each of the specific objectives set at the beginning of the project is satisfactorily met.

The research was carried out on the type of coffee planted in the region of Huautla de Jiménez, turning out to be a type of Arabic coffee of the typical or Creole classification, which is characterized mainly by having low levels of concentration of *caféina*. Highlighting that the coffee residue generated by the company (parchment) is mostly made up of fiber.

The necessary tests were elaborated to obtain fiber from the coffee husk, first throwing a fine powder of light yellow color that, due to the humidity existing in it, over time, began a fermentation process, so it was decided to perform the dehydration of the husk to solve this problem. to which a fine powder of light brown color was achieved; main ingredient for the preparation of whole wheat bread and cookies.

The elaboration of the market study allowed the application of a survey to the number of people who read the sample formula according to the population of the city and target segment. Within the technical study, the description and price of the main machinery was achieved.

The business plan was designed, which determined the profitability of the start-up of the project. To which there was a favorable result, having an average yield greater than 5%, without leaving behind the idea of expanding the variety of products, which will make the yield increase and according to this plan it is estimated to recover the initial investment in year 3.

REFERENCES

- [1] Rathinavelu, R., & Graziosi, G. (2005). *Possible alternative uses of coffee residues and by-products*. Italy: International Coffee Organization.
- [2] Serna Jimenez, J., Torres Valenzuela, L. S., Martinez Cortinez, K., & Hernandez Sandoval, M.C. (2018). Use of coffee pulp

as an alternative for the recovery of by-products. *ion*, 72.

- [3] Rivera, C. A. (2014). *Gastronomic use of the solid waste generated in the food and beverage laboratory of the degree in gastronomy of the UAEM and a restaurant*. Mexico City .
- [4] Figueroa Hurtado , J. G., & Mendoza Abarca, J. (2010). Quantification of materials K, Ca, Mg, P in pulpa and coffee parchment (Coffea arabica L. var Typica). *Venezuelan Journal of FoodScience and Technology*, 221-230.
- [5] Geissman, T. A. (1974). *Principles of organic chemistry*. Los Angeles: revertè s.a.
- [6] Bourges, H., Casanueva , E., & Rosado, J. (2009). *Nutrient intake recommendations for the Mexican population. Physiological bases*. Mexico: Medica Panamericana.
- [7] Casanueva, E., Kaufer-Horwitz, M., Perez Lizaur , A., & Arroyo, P. (2008). *Medical Nutriology* . Mexico: Medica Panamericana.
- [8] Chavez,R., Ramirez,J., & Cassanova,J. (2003). *Heart disease in Mexico and its clinical, epidemiological and preventive importance*. Mexico: Archives of cardiology of Mexico.
- [9] World Health Organization. (s.f.). *Cancer*. Obtenido de <http://www.who.int/cancer/en/>
- [10] Key, T., Schatzkin, A., Willet,W., & Allen, N. (2007). *Diet, nutrition and cancer prevention*.
- [11] Iturra, E. (2018). *Medical Forum* . Mexico, mexico.