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INNOVATIVE EXPERIMENTAL PLANT TO IMPROVE COFFEE PROCESSING

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Abstract: In Mexico, coffee production refers to a process with traditional processing practices that combine rustic and semi-mechanized activities, where quality is not controlled, placing it in the category of conventional coffee. In recent years worldwide, the demand for high-quality coffee has increased and in order to offer this model, it is necessary to standardize the processing and transformation processes that increase the quality and value of the coffee. In order to exploit the different capacities in our country, it is necessary to design an innovative experimental plant for the processing of the primary coffee beneficiary, which is capable of adapting to the processes known by the producers, through the instruments and machinery the plant will provide. The producer has control over the variables that influence taking advantage of the organoleptic properties of the coffee bean prior to harvest. The plant allows experimentation and obtaining controlled results according to the primary processing method to be applied. The development of the experimental plant has three iterative design cycles; 1) concept design, in which the various processes and methods investigated are evaluated to seek their homogenization with the help of instruments for monitoring and control, 2) prototype design, which is carried out with the help of 2D platforms and 3D modeling, that allow visualizing the location of the different equipment, as well as the flows of the different primary processing processes that the producer wishes to apply, and 3) innovation design, in which the products and services allow the value chain to be improved through processes instruments, data control and new techniques. For the development and maintenance of the experimental plant, it is necessary to link the entities that make up the quadruple helix; companies, government, society and public centers and institutes of higher education. In order to promote

teamwork, collaboration and the exchange of ideas to strengthen, sustain and enrich the innovation ecosystem created through the experimental plant.

Keywords: benefited, specialty coffees.

Introduction

The processes of primary processing of coffee are carried out mostly by empirical processes through the knowledge transmitted from generation to generation, in Mexico, these are carried out mainly in the states of Oaxaca, Chiapas, and Veracruz, representing the livelihood for many families. peasant women, however, in recent years the world coffee trade has faced a crisis due to the fall in prices in the international market due to world overproduction, coupled with national problems such as: low yield of plots due to 1) diseases and pests such as rust and borer, 2) aging of coffee plantations (plantations with an average age of between 30 and 40 years), 3) climatic changes such as droughts or abundant rains. Because of this, many Mexican coffee farmers are abandoning this practice (Tovar et al., 2019), increasing poverty and migration. What makes it necessary to generate new strategies that improve the technical, social and economic conditions that allow this activity to be profitable again.

The development of an experimental plant is a new model where the main stakeholders: producers, technicians, academia, civil society and the government, actively participate in an organized manner, appropriating knowledge to generate innovation in the coordinated creation of solutions and new products for offer to the national and international market.

This innovative experimental plant model allows the control of different parameters such as fruit ripening, temperature, humidity, among others, diversifying the primary beneficiary in order to improve the quality of the coffee and therefore its value in the

market that allows Generate a cycle of growth and stability for coffee growers in our country, in addition to promoting the continuous training of new generations through efficient use of resources for the beneficiary and of its residues, giving sustainability to the model.

The main objectives of this model are: a) Generate technical-empirical information that allows the standardization of processes towards obtaining higher quality products, b) Create capacities for experimentation, training and training focused on the generation of new knowledge and new high-value products and c) Promote the marketing of high-value coffee by facilitating regional collection mechanisms and its national and international distribution.

For the development of the experimental plant, there are three iterative design cycles; concept design, prototype design and innovation design.

ANTECEDENTS

Experimental plants are made for research to socialize potential products and services for the market or society, demands for new products and services are generated, socioeconomic and techno-cultural ecosystems are designed, and projects aligned with local, regional, national strategies are proposed. or international.

CIATEQ A.C. is a Public Research Center specialized in advanced manufacturing and industrial processes that performs services, technological development projects, applied research and specialized talent training. It has 42 years of experience in carrying out focused projects for the benefit of society, in which a part of them have been in simulation and analysis for the improvement of their processes and their productivity, likewise the application of methodologies in the development of the projects giving greater value to the results of the projects carried out.

MATERIALS AND METHODS

For the development of the experimental plant, the quadruple helix model was implemented, with the purpose of granting responsibilities to each actor and in the case of CIATEQ, A. C. three iterative cycles were considered; concept design, prototype design and innovation design which have been widely used in the execution of various projects of the center.

The first stage is carried out between the Center for Advanced Technology, (CIATEQ, A. C.) and ``Centro Universitario Regional Sul`` (CRUS) of `` Universidad Autónoma de Chapingo``, in the period of March - June of the year 2019 with the collection of information through field surveys to find out the conventional practices in the cultivation, harvest, processing processes and marketing mechanisms of coffee. These surveys were conducted with various organizations and coffee growers in Oaxaca and Veracruz. In Oaxaca it was carried out in 3 of its 8 regions, the coastal, cañada and mixteca region, in Veracruz in the towns of Coatepec and Zacamitla, visits and meetings were also carried out with suppliers of national and international teams dedicated to the coffee processing process.

In the prototype design and innovation stage, the 2D AutoCAD platforms and SolidWorks 3D modeling were used at the CIATEQ, A. C. Tabasco Unit facilities.

RESULTS AND DISCUSSION

Based on the information obtained from the coffee harvesting, processing and marketing processes, the necessary requirements for the design of the stages of the experimental plant were identified, as well as the definition of the main parameters used by coffee growers in their respective processes.

MAIN RESULTS

Definition of the design bases for the development of the stages shown in Table 1, with the control of each parameter a range of each response variable is sought and these as a whole allow obtaining a quality coffee or called high quality coffee in cup.

CONCEPT DESIGN

The diversity of processes and methods were evaluated to homogenize the conditions and select the necessary instruments for the operation and monitoring of the steps of each primary beneficiary, within the experimental plant, in addition, the organization and requirements of the plant processes were raised. In figure 1 you can see the block diagram of a coffee with honey which is an innovative process within the methods applied in the primary processing of coffee, in figure 2 you can see the block diagram corresponding to the traditional processing process or coffee washing, both processes can be carried out in the experimental plant in a controlled and monitored way.

MAIN RESULTS

- Block diagram for the homogenization of processes.
- Descriptive memory of the various processes.
- Mass and energy balance analysis of the primary coffee processing process.
- Data sheets for the selection of equipment and instruments for the experimental plant.
- Determination of the coffee value chain

EXPERIMENTAL PLANT DESIGN

In order for the experimental plant to be

versatile, all the elements and equipment that will allow the producer to carry out the primary processing processes that provide better results were considered. The proposed design includes the general assembly plan that shows the location of the commercial equipment and components, as well as the flow that the primary processing processes that the producer would like to apply could take.

For the development of the design of the experimental plant, specialized software was supported for the design and modeling in 3D environment, in order to project and visualize the stages that the producer applied to his product during the primary benefit to obtain a measurable, controlled and comparable result. with other processes. Figure 3 shows the design drawing of the experimental plant for the primary mill.

MAIN RESULTS

- Design of an experimental plant for operation by the community.
- Plant operation manuals.
- General concept of operation.

INNOVATION DESIGN

The focus of the experimental plant is to obtain innovative products and services that make it possible to improve the coffee value chain through new techniques, data control, and instrumented processes. In parallel, it is necessary to link the entities of the quadruple helix; companies, government, society, CP/IES. Companies in the development of adequate distribution channels, government in the development of adequate regulations, partnership in the support between coffee growers and public centers and higher education institutes in the phase of experimentation and knowledge development. Whose objective is to improve

Stage	Parameter	Response variable	
Harvest	Fruit ripening	20-25° Brix varieties that predominate in Oaxaca, mainly Typica and Bourbon (Sosa-Maldonado L. 2019).	
		≤ 2.5 % immature fruits	
Wash/Selection	Fruit size/maturation	Fruit density.	
Pulped	Size and weight	Whole grains.	
		fermentation pH	Initial pH 5.9, final pH 4.0 of the fermentation mass (Nigam P.S and Sing A. 2014).
		Fermentation time	From 24 to 36 hours.
Washed	Water quality	The water must be potable according to the parameters established by NOM-127-SSA1-1994.	
		The water must be potable according to the parameters established by NOM-127-SSA1-1994.	
Drying	Elimination of mucilage remains	% humidity 10-12% of grain and AW 0.67.	
		The humidity inside the dryer must not be higher than 3% of the environment, in order to speed up drying and prevent the coffee that is in an advanced drying process from hydrating.	
parchment coffee storage	Relative humidity and room temperature	Relative humidity percentage 63% and 22 °C.	

Table 1. Design bases in coffee stages

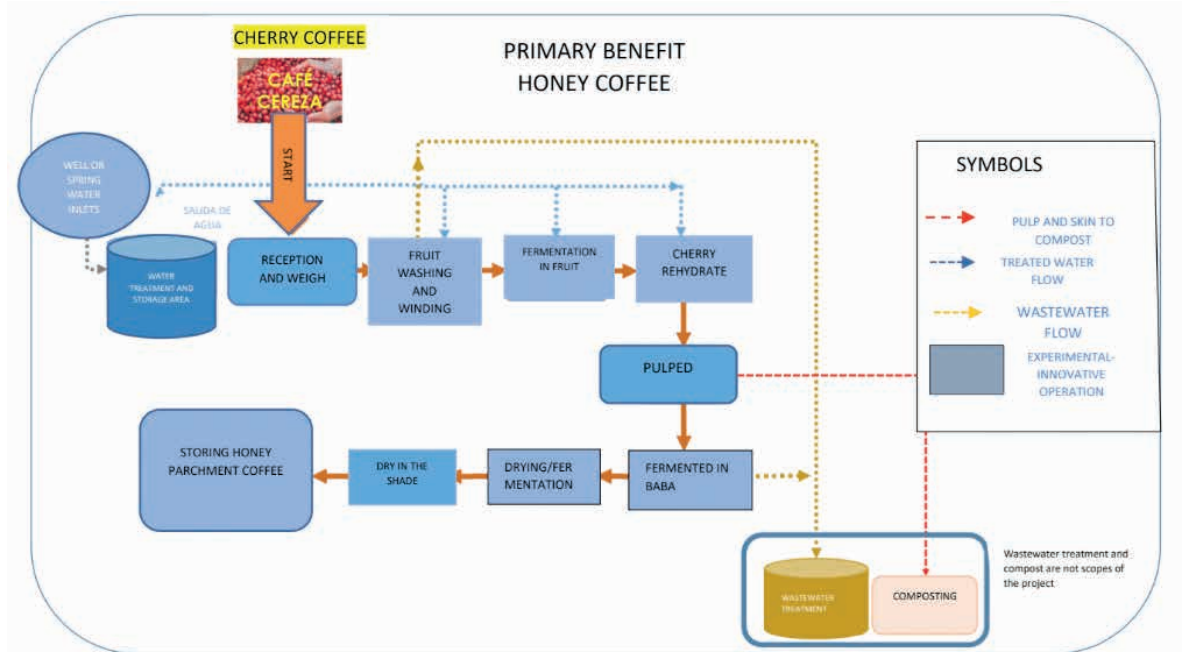


Figure 1 Block diagram of honey coffee processing.

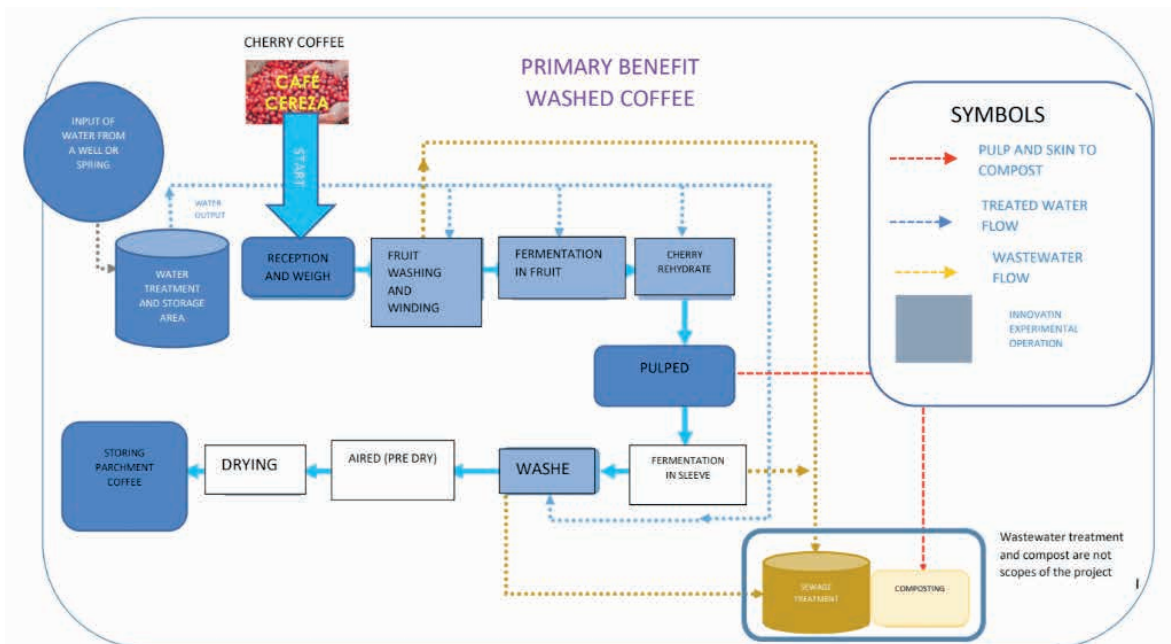


Figure 2 Block diagram of the primary benefit of washed coffee.

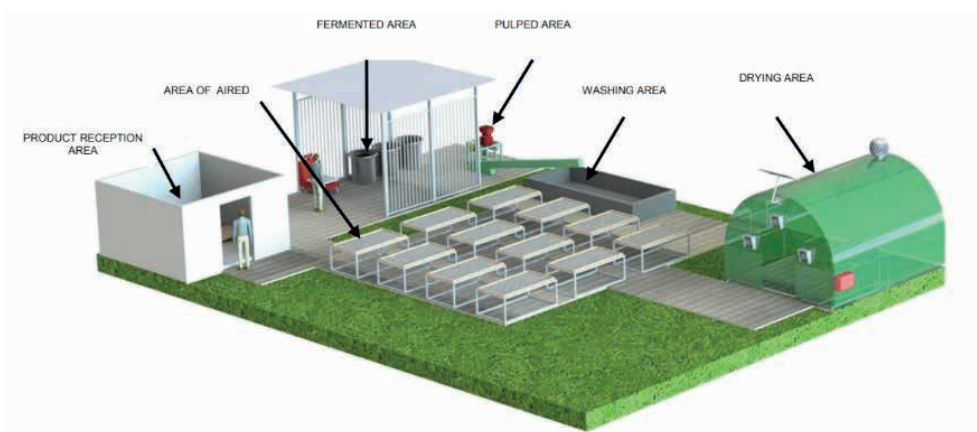


Figure 3. Generic configuration of the Primary Benefit facility.

Equipment	Service
Parchment coffee maquila	Washed
	Honeyed
	Natural
Roasted coffee maquila	In grain
Storage	Parchment coffee
	Roasted coffee beans
Commercialization	Parchment coffee
	Toasted coffee
	Ground coffee
Training	Experimental
	Training

Table 2 list of services offered by the experimental plant for coffee.

the quality of Mexican coffee.

Table 2 shows a list of the equipment for the operation of the experimental plant, and the services or products generated in the operation of each one.

Main results

- Flow chart for specialty coffee.
- Experimental plant operation manual.
- Design of data analysis of the results of the experimental plant.
- Commercial operation model of the experimental plant.
- Business-government-society-public centers/Institutes of higher education integration model.

DISCUSSION

An experimental plant operates in a current context and focuses on the real needs of its participants. The scope, purposes, objectives, duration, and structure of this must be flexible and completely adaptable to the needs of the attendees. This represents an opportunity to generate knowledge and experience to improve the national coffee market and the incorporation of the members of the quadruple helix. Future generations of coffee growers represent an opportunity for the study and improvement of coffee in Mexico.

Conclusions

According to the different data collected during the investigation, Mexican coffee has areas of opportunity to increase its quality, through innovative techniques, in addition to the link that allows the strengthening of this product, which is one of the most important agricultural products in Mexico. Allowing in some even to have their denomination of origin and states such as Chiapas and Veracruz have already made specific regulations, to comply with standards in their processes

(NOM-169-SCFI-2007, Specifications and test methods, NOM-149-SCFI- 2001 VERACRUZ COFFEE-SPECIFICATIONS AND TEST METHODS, NMX-F-013-SCFI-2000 Pure roasted, whole grain or ground coffee without decaffeination or decaffeinated-Specifications and test methods.), however, small coffee growers have less and less motivation since it is difficult for them to comply with it, even the majority do not have the instruments and ways to train future generations.

The experimental plant represents an alternative to strengthen the knowledge and training of future generations in addition to allowing validation in regulatory matters for specialty coffees.

From the analysis of the organizations in the processing processes, we can conclude that it is necessary to develop and innovate in the elaboration of special coffees that allow entering a less competitive market and more profitable costs.

It is essential to develop marketing strategies and mechanisms for small coffee growers in order to allow fair trade and field development.

The experimental plant will be the center to foster Society-Academia-Industry-Government relations (quadruple helix).

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